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ATOMIC ENERGY STATES

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MAGNETIC PHENOMENA

ATOMIC ENERGY STATES

AS DERIVED FROM THE ANALYSES OF OPTICAL SPECTRA

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TO

HARRISON M. RANDALL

PREFACE

At the time that the Bohr theory drew the attention of all physicists to the laws governing the structure of line spectra, the only place where the complete results of such study could be found was in the "Tübingen Dissertation" of Berthold Dunz. This dissertation presented an account of the few spectra in which series relations occurred. More general information was available in Kayser's "Handbuch der Spektroskopie" and Konen's "Das Leuchten der Gase und Dämpfe," but the dissertation of Dunz was the only work which contained all data on series spectra analyzed up to 1911. Later, some important additions to this were given in the dissertation of Lorenser, also made in Tübingen under the direction of Paschen.

In 1922, A. Fowler's "Report on Series in Line Spectra" and F. Paschen's and R. Götze's "Seriengesetze der Linienspektren" appeared nearly simultaneously. Both works contained little more than had been given by Dunz, but the improved material was arranged in agreement with the new theoretical conceptions. In the work of Dunz, for example, the lines of ionized helium had still been mentioned as belonging to hydrogen. While spectra classified previously had been of the singlet, doublet, or triplet sort, Paschen-Götze contained the analysis of a totally different type, the neon spectrum. Both Paschen-Götze and Fowler presented information on the more complicated spectra, O, S, Se, and Mn, although the true multiplet character of these had not yet been recognized.

The appearance of these two books was of the greatest importance, showing as they did how incomplete and unsatisfactory was the knowledge of the structure of line spectra. Research in this direction was greatly stimulated. In 1923, Catalán, working in Fowler's laboratory, analyzed the spectrum of manganese and discovered the "multiplets." At Tübingen the spectrum of chromium was analyzed by Gieseler, and the Zeeman effect of manganese and chromium was observed by Back and Gieseler. This was found to agree completely with the newly developed theory of Landé. Here was the beginning of the modern theory of atomic spectra.

Much progress has been made since then in the theory as well as in the analysis of spectra. Several books and articles have appeared presenting surveys of the theory, but little has been done to gather the results of the classification of spectra. Two books should be mentioned here. First, F. Hund's "Linienspektren und Periodisches System der Elemente" gives an excellent account of the theory up to 1926, and compares the experimental material then known with the theoretical expectations. Data on the analysis of spectra are, however, not given in detail, except in so far as they were needed for this comparison. The second is W. Grotrian's "Graphische Darstellung der Spektren." Volume II of his work contains energy-level diagrams of spectra which, if used with this book, will add much value to the tables we have presented. However, the part of Grotrian's work thus far published deals only with one-, two-, and three-electron spectra.

The tables presented here intend to give the numerical values of the energy levels of atoms and ions investigated up to the present. Energy states arising from the excitation or removal of inner electrons which give rise to x-ray lines are not included in these tables, since they are given together with a complete discussion of the whole field in "Spektroskopie der Röntgenstrahlen" (1931), by M. Siegbahn. Although it took three years to make this compilation, we endeavored to keep the material up to date and believe it to be complete up to the spring of 1931. Considerable work later than this has been included largely through the kindness of spectroscopists in giving us unpublished material.

The references given in these tables are by no means complete. The articles mentioned are only those which contain most of the material concerning the classification of the spectra, and it is obvious that in some cases, therefore, the authors mentioned are not the ones who did the most important pioneer work of the analysis.* A supplementary list of references is included which gives additional references to later work which appeared while these tables were being published.

During the progress of this work, several unexpected difficulties arose. In order to prevent these tables from becoming a useless gathering of numbers, we were obliged to examine all available data critically. For a large number of spectra, "quadratic

* For a complete bibliography we refer to the article by R. C. GIBBS, *Rev. Modern Phys.*, **4**, 278 (1932).

schemes" were made in order to test all observed term combinations. It soon appeared that the results obtained by different authors on the same spectrum were in many cases in contradiction with each other. Furthermore, it sometimes proved to be impossible to decide whose work was correct without going into detailed experimental investigations which were, of course, beyond our means. In a large number of cases, the energy levels found by different authors were the same, but their interpretations, notation, and correlation to electron states differed. Recent developments of the theory* show that this was to be expected. Only in a selected number of special cases is it possible to correlate without ambiguity a definite electron configuration with a given level, using the notation generally adopted at present. In doubtful examples, this correlation is more a matter of personal opinion than of physical significance.

Although we have tried to keep the tables as uniform as possible, the above mentioned difficulties necessarily introduced some inconsistencies. Frequently it was necessary that a choice be made concerning the construction of a table or the notations, and these choices, we know, can only agree in part with those of other workers in the field of spectroscopy. But such choices, we repeat, are a matter of personal opinion only, and preference cannot be based upon physical principles. It may even happen that a given spectrum may be treated differently in these tables from another spectrum of the same type, since we have tried to keep as closely as possible to the original work in order to facilitate reference. The ideal method would have been to ask the opinion of each author separately, but that would have kept the work waiting for another five years at least. We did, however, ask the opinion of as many as we could, and at this place wish to thank them for their valuable suggestions. We also wish to ask forgiveness of those authors who feel that we have mutilated the results of their investigations too greatly.

These tables have been compiled with material aid from the Department of Physics of the University of Michigan. The facilities of this department were constantly at our disposal, for which we are under deep obligation to Professor H. M. Randall. Several colleagues helped us directly in the work. Our thanks are first due to Dr. R. A. Fisher, at present at North-

* E. U. Condon, *Phys. Rev.* **36**, 1121 (1930).

western University, for continuous assistance in the organization of these tables. We also wish to thank Dr. I. S. Bowen, Dr. R. J. Lang, Dr. O. Laporte, Dr. J. E. Mack, Dr. W. F. Meggers, Dr. R. A. Sawyer, and Dr. A. G. Shenstone for their valuable help, and Professor F. Paschen for permission to reprint his Rydberg Tables.

In conclusion, we wish to express the hope that these tables may encourage further work in the analysis of spectra. We believe they show clearly that comparatively few spectra have been investigated satisfactorily. Spectroscopic data are still of much importance as a test for the laws of quantum mechanics. We are of the opinion that further research along these lines will reveal new truths which are essential for progress in the theory of matter.

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SAMUEL GOUDSMIT.

DEPARTMENT OF PHYSICS,
UNIVERSITY OF MICHIGAN,
September, 1932.

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Following the atomic number Z and the chemical symbol for each element, the number in *italics* gives the page at which the term tables for the element start. Spectroscopically homologous elements are found in the same horizontal row; however 57 La might well have been put in the place occupied by 71 Lu.

The last column gives the configurations which are the most stable ones for the neutral atoms in the row and the Russell-Saunders symbol for the lowest level of each configuration. The rare earths, $Z = 58$ to 71, are supposed to have as lowest states configurations of the type $f^x ds^2$, but none of them has been analyzed sufficiently to make this assignment certain. The spectra of the heaviest four elements have also not been analyzed; their lowest configurations and their position in this table are uncertain.

ATOMIC ENERGY STATES

INTRODUCTION*

1. Energy States.—Each atomic spectral line is connected with the transition of an atom or an ion from one quantum state or energy level with a definite energy E_1 to another one with E_2. The frequency $\tilde{\nu}$ (in vibrations per second) of the emitted spectral line is according to the Bohr frequency relation

$$\tilde{\nu} = \frac{E_1 - E_2}{h} \text{ sec.}^{-1} \qquad (1)$$

where h is Planck's constant. The analysis of the structure of a spectrum consists primarily in determining the energy states of the given atom or ion from the frequencies of the observed spectral lines. The tables in this book are a compilation of these energy states.

2. Units.—The units used for the energy of the quantum states in spectroscopic work are such that the difference between two states gives at once the wave number, that is the number of waves per centimeter (denoted by ν), for the emitted spectral line. In these units Eq. (1) becomes

$$\nu = \frac{\tilde{\nu}}{c} = \frac{E_1}{hc} - \frac{E_2}{hc} \text{ cm.}^{-1} \qquad (2)$$

where c is the velocity of light. The numbers inserted in these tables are thus energies divided by hc and have the dimension cm.$^{-1}$. The energy states expressed in these units are generally called *terms* and their values *term values*. For the relations between the different units in which energy is expressed, see page 556.

3. Relative and Absolute Term Values.—It follows from Eq. (1) that the spectroscopic material gives us only the differences between the various energy states. The values in the tables are obtained by choosing one of the term values equal to zero.

* This introduction does not attempt to give a complete theory of the structure of spectra but contains only what is necessary to understand the spectroscopic notation and the construction of the following tables.

In many cases one puts the state with the lowest energy equal to zero, in which case the term values of all other states will be positive numbers, increasing with the height of excitation. Sometimes it happens that in a single spectrum different groups of energy levels have been found, but one has not been able to determine their relative positions. In such a case one usually puts the lowest energy state within each group equal to zero. None of these need, however, be actually the lowest state of the entire system.

In other spectra which have been analyzed more completely, it is often possible to calculate with great precision the energy necessary to remove one electron from the lowest or normal state to an infinite distance, *the ionization energy*. In these spectra it is customary to put the energy of the state in which this electron is removed completely, *the ionization limit*, equal to zero. The other states of the atom, therefore, have negative energies, the normal state having the largest negative energy. In the term values for such spectra, however, one always omits the minus sign and denotes the term values by positive numbers, the largest one for the lowest state. If one electron is excited, the term values decrease and converge to the value zero. However, it also occurs in many such spectra that two electrons are excited at the same time making the total energy of excitation, calculated from the lowest state, more than the energy necessary to remove one electron entirely. These energy states are higher than the ionization limit and are denoted by negative numbers; the higher the terms, the larger will be their negative values. The term values in spectra where the ionization limit is put equal to zero are called *absolute* term values.

The tables in this book begin with the lowest state. When the term values decrease, one knows that they are *absolute*, and when they increase that they are *relative* term values.

4. Odd and Even Terms.—The analysis of spectra shows that the levels of each spectrum can be divided into two groups, *even* and *odd* terms. They are distinguished by the fact that transitions occur only between an odd state and an even one, not between two odd or two even states. The reason for these names will be explained in Sec. 8. Though this rule concerning the transitions is not strictly obeyed, it is always possible, as is shown by both theory and experience, to make the division into the two groups without any ambiguity.

Transitions between two odd or two even terms occur usually under the influence of disturbing electric fields, either external ones or from neighboring atoms. However, even under "normal" conditions, such "forbidden" transitions may occur (quadrupole radiation), but they are then very much weaker than the non-forbidden transitions involving the same terms. Such forbidden lines appear prominently in the spectra of nebulae.*

5. J Values.—To each one of the energy states corresponds a definite value of the angular momentum of the total system of electrons. The angular momentum is measured in units $h/2\pi$, and its value in these units is denoted by J. For spectra with an even number of electrons, J has integer values; for an odd number, half-integer values. The values of J can be determined by the selection rule that only those transitions occur in which J changes by 1, 0, or -1, with the addition that the transition $J = 0 \rightarrow J = 0$ is forbidden.

The selection rule for J may be violated under the influence of magnetic fields strong enough to cause a Zeeman effect splitting of the same order as the distance between neighboring levels. Under these circumstances, however, it is no longer possible to attribute to a given level a definite J value without ambiguity. In these tables we shall consider the spectra only without the influence of magnetic fields.†

6. Ambiguity of Further Quantum Numbers.—Of the quantum numbers which are used to denote the different energy states, and which we shall discuss in the following sections, only the angular momentum J has in all general cases a strict physical meaning and it can therefore always be determined without ambiguity, provided the experimental data are sufficient. It is, furthermore, always possible to distinguish between odd and even levels. One requires from the analysis of a spectrum much more than just these properties, since one wishes to have detailed information about the configuration of the electrons for each one of the energy states. Before discussing this in detail we want to stress that such a correlation has in general no strict

* Compare Sec. 14.

† The same difficulty which may arise in the presence of a magnetic field can also occur in case the hyperfine structure caused by nuclear magnetism is sufficiently large, compared to the distance of neighboring levels. Such large hyperfine structure will very probably never occur in actual spectra; the hyperfine structure of ionized Li comes nearest to such a case.

physical meaning, except in a number of simple examples. Controversies have occurred concerning the quantum numbers of energy states in complicated configurations, the decision of which depended entirely on personal opinion and certain preferences. For instance, considering the intensities of lines connected with a level, one might come to a conclusion about the electron configuration and its quantum numbers; whereas, if one studies the Zeeman effect of the same level, one is led to a different result. Theory, in agreement with experience, shows that the quantum numbers which one tried to correlate to that level are meaningless for such a case.

7. One Electron.—The quantum numbers which denote the energy states for an atom consisting of closed electron groups and one single electron are mainly those of that single electron, namely,

n the principal quantum number, related to the size of the orbit in the Bohr model.

l the angular momentum of the orbital motion in quantum units $h/2\pi$. l can have integer values only.

s the spin moment of the electron in the same units. For every single electron $s = \frac{1}{2}$.

j the resultant angular momentum. It can have the values $l - \frac{1}{2}$ and $l + \frac{1}{2}$, except for $l = 0$, where only $j = \frac{1}{2}$ is possible. The level with $j = l - \frac{1}{2}$ is practically always below that with $j = l + \frac{1}{2}$.

Special symbols are used to denote the value of l for an electron, namely,

$$\begin{array}{rcccccccc} l = & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \;\ldots \\ \text{Symbol} & s & p & d & f & g & h & i & k \;\ldots \end{array}$$

The value of the principal quantum number n is put in front of this symbol, thus

$$n = 5,\ l = 2,\ \text{symbol } 5d.$$

Sometimes the value of j is put as a subscript to the symbol, for example

$$5d_{1\frac{1}{2}},\ 5d_{2\frac{1}{2}},\ 3s_{\frac{1}{2}},\ \text{etc.}$$

The symbols described above are used only to denote the individual electron. If one considers the energy level, one uses different symbols. This distinction is somewhat misleading in

the case of a single electron, where it seems quite unnecessary, but it is very useful for more general cases. We shall, therefore, discuss these symbols in the following section.

It must be mentioned that in the case of a one-electron spectrum all quantum numbers can be given without ambiguity, provided, of course, that the spectrum is sufficiently known.

8. Many Electron Configurations.—An electron *configuration* is characterized by the values of the quantum numbers n and l for all electrons present. Two configurations differ in at least one of the n's or l's of the electrons. A configuration is denoted by means of the symbols described in Sec. 7. When several electrons have the same value for n and l, their number is denoted by an exponent, for instance,

$$2p^3\, 3s\, 3p$$

which means: three electrons with $l = 1$, $n = 2$; one with $l = 0$, $n = 3$; one with $l = 1$, $n = 3$. One places the electrons in order of their n, and for the same n in order of l. For many electrons one usually gives the symbols for only the outermost ones, because the innermost groups are not changed in the excitation of the energy states.

When the arithmetical sum of all l's of the electrons is *even*, one obtains *even* energy levels; and, in the other case, *odd* ones. The symbols for odd levels are distinguished by the sign ° at the upper right side and the term value printed in *italics*.

Each configuration gives rise to a number of energy states; thus many energy states belong to the same configuration. One of the main problems in the analysis of a spectrum is to determine to which electron configuration each term belongs. Recent theoretical investigations show that this cannot always be done unambiguously. For instance, when nearly all levels arising from an odd configuration lie isolated from those of other odd configurations, it is practically possible and has also a definite meaning to correlate these levels to that configuration. However, when the level groups of two odd configurations intermix, it no longer has a physical sense to distinguish between the two configurations and it is also practically impossible to choose without ambiguity the levels which belong to each of the two coinciding configurations.* The same, of course, holds for even levels, but when the levels of an even configuration overlap with

* E. U. Condon, *Phys. Rev.* **36**, 1121 (1930).

those of an odd one they have no mutual influence on each other and are still distinguishable.

There exist certain special, more or less accidental, cases in which the theory shows that two odd or two even levels may come close together without perturbing each other. This occurs, for example, in one-electron spectra, where the s levels and d levels often come close together but are always distinguishable. For more general configurations usually only the ones with the lowest energy can be distinguished from the others. Those with higher energy have their energy levels so mixed up that the configurations lose their individuality.

9. Russell-Saunders Coupling.—In several-electron configurations, especially those occurring in simpler spectra, the interactions between the electrons are such that the spin moments s of the individual electrons form, together, a definite resultant spin moment S and, in the same way, their orbital moments l form a resultant orbital moment L. For this kind of interaction, the so-called Russell-Saunders coupling,* a special notation is used to denote the terms which we shall describe now.

As the spin for each single electron is $s = \frac{1}{2}$, the resultant spin S for, say, x electrons can have all values up to $\frac{x}{2}$, differing by unity. Thus, if x is even, S can be 0, 1, 2, . . . $\frac{x}{2}$; for x odd, $S = \frac{1}{2}, 1\frac{1}{2}, 2\frac{1}{2}, \ldots \frac{x}{2}$. A given spectrum contains only states with integer or half-integer values of S. For a given configuration, the same value of S can occur several times by combining the s of the individual electrons in different ways.

The values of the resultant orbital momentum L depend in a more complicated way upon the individual l values. For two electrons, L is limited by

$$|l_1 - l_2| \leq L \leq l_1 + l_2 \tag{3}$$

For more electrons, one can obtain the possible values for L by first combining two l's and then combining each possible resultant with the third l, etc. The value of L is always integral; here also the same value can occur many times from different combinations.

* H. N. Russell and F. A. Saunders were the first to find and recognize such configurations in their important work on the spectra of the alkaline earths; *Astrophys. Journ.* **61**, 38 (1925).

The total angular momentum J is the resultant of S and L, and for given values of these quantum numbers is limited by

$$|L - S| \leq J \leq L + S \tag{4}$$

When an atom contains an odd number of electrons J is a half-integer, with an even number of electrons it is an integer.

The following names and symbols are used for energy states which can be given definite values of L and S:

$L =$	0	1	2	3	4	5	6	7 . . .
Symbol	S	P	D	F	G	H	I	K . . .

$S = 0$, singlet
$\frac{1}{2}$, doublet
1, triplet
$1\frac{1}{2}$, quartet
2, quintet
Etc.

The names connected with the various values of S are called* the *multiplicities*. They originate from the fact that for a given S and L there are $(2S + 1)$ possible values for J, provided one chooses $L \geq S$. These levels lie together in a group called a *multiplet*. In the symbols for the terms, the multiplicity, that is the number $(2S + 1)$ is added as a superscript to the left side of the symbol representing L, thus

$$^2S,\ ^5D,\ ^4P.$$

It must be noted that the multiplicity is always given as $(2S + 1)$, even when the number of possible J values, which are added as subscripts, is less than $(2S + 1)$.

For instance,

^3D means $S = 1$, $L = 2$. Possible J values 1, 2, 3: symbol for the three levels $^3D_1$, $^3D_2$, $^3D_3$.
^6P means $S = 2\frac{1}{2}$, $L = 1$. Only three possible J values: $1\frac{1}{2}$, $2\frac{1}{2}$, $3\frac{1}{2}$; symbols $^6P_{1\frac{1}{2}}$, $^6P_{2\frac{1}{2}}$, $^6P_{3\frac{1}{2}}$.

Such a group of levels which differ only in their values of J (a multiplet) shows in an ideal case a simple relation between the distances of the levels, the Landé *interval rule*. The levels lie

* One should not confuse the symbols s and S denoting the spin vectors with the same letters used for states for which respectively l or L is zero.

in order of their J values, and their separations are proportional to the larger J value, for example,

$$\begin{array}{lccccccccc} & {}^7D_1 & & {}^7D_2 & & {}^7D_3 & & {}^7D_4 & & {}^7D_5 \\ \text{Separations} & & 2A & & 3A & & 4A & & 5A & \end{array}$$

The proportionality factor A is called the *separation factor*. In most actual examples this interval rule is only approximately fulfilled.

When the level with the largest J has the highest energy, A is taken positive and one calls the multiplet *regular*. In the opposite case, the multiplet is *inverted*, and A negative.

The complete symbol for an energy level in the case of Russell-Saunders coupling consists of the configuration symbol and that denoting the resultant S, L, and J.

We shall now give a few examples.

One electron: Resultant $S = s = \frac{1}{2}$, doublets.

$$7p\ {}^2P_{1\frac{1}{2}} \text{ means } n = 7,\ l = L = 1,\ S = \tfrac{1}{2},\ J = 1\tfrac{1}{2}$$

For this simple case the complete notation is somewhat too elaborate.

Two electrons: Configuration $3p\ 3d$, thus $l_1 = 1$, $l_2 = 2$, $L = 1$, 2, or 3. $S = 0$ or 1. This configuration gives rise to the following 12 terms gathered in Table I.

TABLE I.—STATES ARISING FROM A p AND A d ELECTRON

	$S = 0$, singlets			$S = 1$, triplets				
$J =$	1	2	3	0	1	2	3	4
$L = 1$..................	${}^1P_1$	...	...	${}^3P_0$	${}^3P_1$	${}^3P_2$		
2..................	...	${}^1D_2$	...	...	${}^3D_1$	${}^3D_2$	${}^3D_3$	
3..................	...	...	${}^1F_3$	...	...	${}^3F_2$	${}^3F_3$	${}^3F_4$

The complete symbol for one of them would be

$$3p\ 3d\ {}^3D_2{}^\circ$$

denoting, one electron with $n = 3$, $l = 1$; one electron with $n = 3$, $l = 2$; resultant $S = 1$; resultant $L = 2$; total resultant $J = 2$. For simple configurations the multiplet with largest L and S lies lowest, but no further general rule can be given for their positions.

Three electrons: Configuration $3s\,3d\,4p$. The first two* give $S' = 0$ or 1. Adding the third gives $S = \frac{1}{2}, \frac{1}{2}, 1\frac{1}{2}$. The value $\frac{1}{2}$ arises twice, once from adding the spin moment of the third electron to the resultant $S' = 0$ of the first two, and once combining it with $S' = 1$.

In a similar way one finds the values 1, 2, and 3 for the resultant L. This configuration gives thus

$$^2P^\circ,\ ^2P^\circ,\ ^2D^\circ,\ ^2D^\circ,\ ^2F^\circ,\ ^2F^\circ,\ ^4P^\circ,\ ^4D^\circ,\ ^4F^\circ$$

A complete symbol is, for instance,

$$3s\,3d\,4p\ ^4P_{\frac{1}{2}}^\circ$$

Here a new difficulty arises. Each of the doublets occurs twice, and it is necessary to distinguish them in the term symbols. We obtained the two sets of doublets by first considering the $3s$ and $3d$ electron and later adding the $4p$ electron. This often occurs in the actual atom in the same way. One considers the possible energy states of the ion containing the $3s\,3d$ configuration, and can tell to which state of this ion the $4p$ electron has been added. To distinguish between the two sets of doublets, one must write

$$3s\,3d\,(^3D)\,4p\ ^2F^\circ \quad \text{and} \quad 3s\,3d\,(^1D)\,4p\ ^2F^\circ$$

The first symbol denotes that the $4p$ electron can be thought of as being added to the ion when it was in the state with $S' = 1$, $L' = 2$; the second, when $S' = 0$, $L' = 2$. In a practical case one can decide this by considering the position of the two doublets. If, for instance, in the ion of this example the ^1D state is considerably higher than the ^3D state, the ^2F built on the former will lie about the same amount higher as the ^2F built upon the latter.

When a configuration contains more than one electron of the same n and l, the Pauli exclusion principle does not allow all terms which we predict by combining the quantum vectors to be realized. The terms which occur for equivalent electrons are assembled in Table II. For details about the Pauli principle and its theory we refer to L. Pauling and S. Goudsmit, "Structure of Line Spectra," Chap. IX.

10. Limitation of Russell-Saunders Coupling.—As was mentioned above, the Russell-Saunders coupling must be considered

* We use the symbol S only for the total resultant spin of all electrons under consideration and use S' for the spin resultant of a part of the electrons.

TABLE II*

Equivalent s Electrons

$s - {}^2S$

$s^2 - {}^1S$

Equivalent p Electrons

p^1 –		^2P		
p^2 –	^1S		^1D	^3P
p^3 –		^2P	^2D	^4S
p^4 –	^1S		^1D	^3P
p^5 –		^2P		
p^6 –	^1S			

Equivalent d Electrons

d^1	–		$^2(D)$							
d^2	–	$^1(SDG)$		$^3(PF)$						
d^3	–		$^2(D)$			$^2(PDFGH)$	$^4(PF)$			
d^4	–	$^1(SGD)$		$^3(PF)$	$^1(SDFGI)$		$^3(PDFGH)$		$^5(D)$	
d^5	–		$^2(D)$			$^2(PDFGH)$	$^4(PF)$	$^4(SDFGI)$	$^4(DG)$	$^6(S)$
d^6	–	$^1(SGD)$		$^3(PF)$	$^1(SDFGI)$		$^3(PDFGH)$		$^5(D)$	
d^7	–		$^2(D)$			$^2(PDFGH)$	$^4(PF)$			
d^8	–	$^1(SGD)$		$^3(PF)$						
d^9	–		$^2(D)$							
d^{10}	–	$^1(S)$								

Equivalent f Electrons

f^1	$^2(F)$			
f^2	$^1(SDGI)$	$^3(PFH)$		
f^3	$^2(PDFGHIKL)$	$^4(SDFGI)$		
	2 2 2 2			
f^4	$^1(SDFGHIKLN)$	$^3(PDFGHIKLM)$	$^5(SDFGI)$	
	2 4 4 2 3 2	3 2 4 3 4 2 2		
f^5	$^2(PDFGHIKLMNO)$	$^4(SPDFGHIKLM)$	$^6(PFH)$	
	4 5 7 6 7 5 5 3 2	2 3 4 4 3 3 2		
f^6	$^1(SPDFGHIKLMNQ)$	$^3(PDFGHIKLMNO)$	$^5(SPDFGHIKL)$	$^7(F)$
	4 6 4 8 4 7 3 4 2 2	6 5 9 7 9 6 6 3 3	3 2 3 2 2	
f^7	$^2(SPDFGHIKLMNOQ)$	$^4(SPDFGHIKLMN)$	$^6(PDFGHI)$	$^8(S)$
	2 5 7 10 10 9 9 7 5 4 2	2 2 6 5 7 5 5 3 3		
f^8	$^1(SPDFGHIKLMNQ)$	$^3(PDFGHIKLMNO)$	$^5(SPDFGHIKL)$	$^7(F)$
	4 6 4 8 4 7 3 4 2 2	6 5 9 7 9 6 6 3 3	3 2 3 2 2	
f^9	$^2(PDFGHIKLMNO)$	$^4(SPDFGHIKLM)$	$^6(PFH)$	
	4 5 7 6 7 5 5 3 2	2 3 4 4 3 3 2		
f^{10}	$^1(SDFGHIKLN)$	$^3(PDFGHIKLM)$	$^5(SDFGI)$	
	2 4 4 2 3 2	3 2 4 3 4 2 2		
f^{11}	$^2(PDFGHIKL)$	$^4(SDFGI)$		
	2 2 2 2			
f^{12}	$^1(SDGI)$	$^3(PFH)$		
f^{13}	$^2(F)$			
f^{14}	$^1(S)$			

* From the tabulation of R. C. Gibbs, D. T. Wilber, and H. E. White, *Phys. Rev.* **29**, 790 (1927). The sign ° to denote odd terms has been omitted in these tables.

as a special case of interaction between the electrons. It occurs when the electrostatic interaction between the different electrons,

which causes the distances between multiplets, is much larger than the spin-orbit interactions, producing the separations within each multiplet. This will generally hold for atoms having a small nuclear charge. But as the spin-orbit interaction increases more rapidly with increasing nuclear charge than do the electrostatic interactions, one must expect deviations from Russell-Saunders coupling for larger nuclear charges or highly ionized atoms. It also occurs that some configurations in an atom show Russell-Saunders coupling, and others do not. For example, if one considers two electrons, one in a low energy state and the other in a highly excited state, the spin-orbit interaction of the first may be larger than its interaction with the second one. If one now brings the second electron nearer in a less excited state, its interaction can become so large as to cause Russell-Saunders coupling. In such a case low states will show Russell-Saunders coupling; higher ones will not.

In the energy scheme the deviations from the Russell-Saunders coupling will be characterized by deviations from the interval rule. The various multiplets of a configuration begin to overlap. The Zeeman effect, characterized by the Landé g values, shows deviations from the theoretical expectations for extreme Russell-Saunders coupling. As the deviations become larger, there no longer exists a definite resultant spin moment S and orbital moment L; it becomes impossible to distinguish between the different multiplets of the same configuration without ambiguity, and the symbols described in the previous section can no longer be used, or, if they are used, they are meaningless and misleading.

The extreme Russell-Saunders coupling is the only one in which a comparatively simple notation for the energy states gives all required information. This has led many spectroscopists to use the same symbols in cases where they should not be used because of too large deviations from Russell-Saunders coupling.* This misuse has become so general that it was in

* One of the worst examples is the treatment of the neon spectrum by S. Goudsmit, *Zeits. f. Physik.* **32**, 794 (1925). Since then one still uses the Russell-Saunders notation for the $p^5 s$ configurations in this and similar spectra, even though this notation is here quite meaningless. In a very few selected cases it is possible to determine what would happen to each level of a configuration if one could change gradually to extreme Russell-Saunders coupling. The configuration $p^5 s$ is such an example and this explains why the use of the Russell-Saunders notations, though being meaningless, has not led to any ambiguity in this special case.

many cases impossible to remove it from this compilation of term tables, without the possibility of causing misunderstanding!

11. (j, j) **Coupling.**—Another extreme coupling, which rarely occurs, is that in which the spin-orbit interaction for each electron is much larger than the interaction between different electrons. In this case each electron has its own individual resultant j, and the j's of all electrons combine together to form the resultant J. A symbolic designation for this coupling and the Russell-Saunders coupling is

(j, j) Coupling: $(l_1, s_1)\ (l_2, s_2)\ (l_3, s_3) \cdots = (j_1, j_2, j_3 \cdots) = J$
Russell-Saunders Coupling:

$$(l_1, l_2, l_3 \ldots)\ (s_1, s_2, s_3 \ldots) = (L, S) = J$$

The grouping of the levels in this coupling is quite different from the multiplet grouping. We shall give a simple example of two electrons.

Configuration $3p\ 3d$: $j_1 = \frac{1}{2}$ or $1\frac{1}{2}$, $j_2 = 1\frac{1}{2}$ or $2\frac{1}{2}$

The lowest energy states will be those for which $j_1 = \frac{1}{2}$ and $j_2 = 1\frac{1}{2}$. This case will give rise to two levels, $J = 1$ and $J = 2$. Supposing the $3d$ electron to have a smaller spin-orbit interaction than the $3p$ electron, one will find next higher the levels for which $j_1 = \frac{1}{2}$ and $j_2 = 2\frac{1}{2}$. There are again two levels, $J = 2$ and 3. Their distance from the former two will be just the doublet separation of the $3d$ electron, if it were alone present. Next higher, one finds the levels for which $j_1 = 1\frac{1}{2}$ and $j_2 = 1\frac{1}{2}$, this time four, $J = 0, 1, 2, 3$. Their distance from the lowest group is just the doublet separation of the $3p$ electron. The highest group is the one for which both electrons have their highest j value, $j_1 = 1\frac{1}{2}$, $j_2 = 2\frac{1}{2}$, four levels $J = 1, 2, 3, 4$. The result is presented in Table III. One sees at once that it differs considerably from the multiplet structure.

For equivalent electrons the Pauli principle again excludes a number of levels. The ones occurring are given in Table IV. They are arranged according to the j values for the individual electrons, the lowest group first.

It would not be difficult to devise a notation for this extreme coupling, but it occurs too rarely to be of any use.

12. Intermediate Coupling.—In most spectra a coupling occurs which is neither extreme Russell-Saunders nor extreme (j, j) type. No symbols can conveniently be used and all one can do is

to number the levels belonging to each configuration. And, in cases where one can no longer even distinguish between the different configurations, all that can be done is to number all levels in some arbitrary way, denote whether they are odd or even, and give their J values.

TABLE III.—*pd* CONFIGURATION IN (j, j) COUPLING

p	d	J
$j_1 = \frac{1}{2}$	$j_2 = 1\frac{1}{2}$	1 2
$\frac{1}{2}$	$2\frac{1}{2}$	2 3
$1\frac{1}{2}$	$1\frac{1}{2}$	0 1 2 3
$1\frac{1}{2}$	$2\frac{1}{2}$	1 2 3 4

TABLE IV.—ALLOWED STATES FOR EQUIVALENT ELECTRONS WITH (j, j) COUPLING*

	Sub-groups		J values
$j_i =$	$\frac{1}{2}$	$1\frac{1}{2}$	
p^2	2		0
	1	1	1 2
		2	0 2
p^3	2	1	$1\frac{1}{2}$
	1	2	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$
		3	$1\frac{1}{2}$
$j_i =$	$1\frac{1}{2}$	$2\frac{1}{2}$	
d^2	2		0 2
	1	1	1 2 3 4
		2	0 2 4
d^3	3		$1\frac{1}{2}$
	2	1	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$
	1	2	$\frac{1}{2}$ $1\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$
		3	$1\frac{1}{2}$ $2\frac{1}{2}$ $4\frac{1}{2}$
d^4	4		0
	3	1	1 2 3 4
	2	2	0 0 1 2 2 2 2 3 3 4 4 4 5 6
	1	3	0 1 1 2 2 3 3 3 4 4 5 6
		4	0 2 4
d^5	4	1	$2\frac{1}{2}$
	3	2	$\frac{1}{2}$ $1\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$
	2	3	$\frac{1}{2}$ $\frac{1}{2}$ $1\frac{1}{2}$ $1\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $3\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$ $4\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$ $6\frac{1}{2}$
	1	4	$\frac{1}{2}$ $1\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $2\frac{1}{2}$ 9 $3\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$
		5	$2\frac{1}{2}$

* From PAULING and GOUDSMIT, "Structure of Line Spectra," p. 258.

An especially important type of intermediate coupling is the one which occurs, for example, in neon. Consider the configuration $3p\ 6d$. It can happen that the interaction between the two electrons is smaller than the spin-orbit interaction of the $3p$ electron, but larger than that of the $6d$ electron. In such a case it is possible to ascribe a definite value of j to the $3p$ electron but not to the $6d$ electron. The addition of the $6d$ electron, when the $3p$ electron is in the $3p\ ^2P_{\frac{1}{2}}$ state, will give rise to four levels, with $J = 1, 2, 2$ and 3. These levels will be grouped near together. They certainly must be closer together than the doublet separation of the p electron, according to our assumption that the interaction with the added d electron is smaller than the spin-orbit interaction of the p electron. These are the same as in the example in Sec. 11, but in that case they were subdivided into two groups, one for which the d electron had $j = 1\frac{1}{2}$, the other for which it had $j = 2\frac{1}{2}$. In the same way our previous example gave us two more groups of levels when the d electron was added to the p electron in its $^2P_{1\frac{1}{2}}$ state. Here, however, these two groups can no longer be distinguished and they overlap so as to form one group of eight levels with J values 0, 1, 1, 2, 2, 3, 3, 4. Thus, the addition of the d electron has simply split each of the levels of the p doublet into a number of levels grouped together; the distance between the two groups is roughly equal to the doublet separation of the p electron alone.

In a general case one can have an electron added to a multiplet state of an ion in such a way that the interaction is weaker than the energy difference between the levels of the multiplet of the ion. In the above example the multiplet happened to be a doublet, and the addition of an electron in a definite state gave rise to two groups of energy levels. If the ionic state is a triplet, the spectrum will have its energy levels in three groups, their distances being approximately those of the triplet separation of the ion.

13. Multiple Series Limits.—It was mentioned in Sec. 3 that it is often possible to calculate from spectroscopic data the energy necessary to remove one electron entirely. This is done in the following way. Consider the configurations which differ only in the value of n of one of the electrons. For instance, consider the sequence of terms

$$3p\ 3d\ ^1F_4;\ 3p\ 4d\ ^1F_4;\ 3p\ 5d\ ^1F_4;\ \ldots$$

When the coupling is not of the Russell-Saunders type, one should choose by preference a level of which the J value occurs only once in the configuration. According to the theory and in agreement with experience, the energies of such a sequence must follow a formula of the following type, the so-called Rydberg-Ritz formula,

$$E = -\frac{Rhc}{\left(n - \alpha + \frac{\beta}{n^2}\right)^2} \tag{5}$$

where R is the Rydberg constant and α and β are constants, the latter usually being very small. These energies are chosen in such a way that for $n = \infty$, that is, when the electron is removed, the energy is zero. When a sufficient number of levels in the sequence is known, one can determine the constants of the formula with great accuracy and obtain the absolute term values. In wave numbers and omitting, as usual, the minus sign, the formula for the terms becomes

$$T = \frac{R}{\left(n - \alpha + \frac{\beta}{n^2}\right)^2} \tag{6}$$

Such a sequence is called a *term series.*

When all sequences under consideration consist of levels built upon the same state of the ion, they will all have the same level $E = 0$. In a diagram representing these sequences one will actually see them converge to the same series limit, the ionization limit. This limit represents the state of the ion on which the levels of the series are built and in which the ion will be found if one actually removes the electron. In only a few cases, however, are all the known levels for a spectrum built upon the same state of the ion. Several spectra have series built upon different states of the ion and, therefore, converging to several different limits.*

This complication causes difficulties in the use of absolute term values. It is necessary to mention the state of the ion from which the absolute term values are calculated. This state is, in fact, the series limit of only a few of the series of the entire spectrum.

It also follows that an atom has more than one ionizing energy. The principal or *first ionizing energy* is the energy necessary to

* Compare the example on page 9.

remove an electron from the very lowest state of the atom so as to obtain the very lowest state of the ion on which it is built.

14. Selection Rules.—The selection rules are the rules which govern the transitions between the different energy levels of an atom. These selection rules are valid only under "normal conditions," an expression which is hard to define rigorously. One can say approximately that the spectrum must be produced by an atomic gas in temperature equilibrium not disturbed by external electric or magnetic fields. The pressure may not be too high, as it is necessary to avoid mutual disturbance of the atoms in the gas; nor may it be too low, for the number of collisions must be large enough to keep the equilibrium distribution intact. It is perhaps better to understand what is meant by "normal conditions" by considering under what circumstances the various selection rules are violated.

A *metastable level* is an energy state from which there is no transition possible to any one of the states with lower energy, due to the selection rules. The very lowest level of the atom is, of course, not considered as a metastable one. The metastable levels play a very important rôle in the excitation of spectra. Under normal conditions an atom in a metastable state will lose its energy only in a collision.

The following are the selection and transition rules:

1. *Transitions occur only between an odd and an even level.* This selection rule is violated under the influence of disturbing electric fields from neighboring atoms or from external sources. Another type of violation of this rule occurs in the nebular spectra where the pressure is so low that collisions practically never occur. This causes the accumulation of a large number of atoms in metastable states. Under these circumstances the probability that the atom emits its energy in the form of radiation and falls into the lowest state is much larger than that it loses its energy in a collision. This is why one observes such forbidden spectral lines in nebular spectra.* This important and highly interesting explanation of the puzzling nebular spectra was discovered by I. S. Bowen,† to whose articles we refer for further details.

* The radiation involved is quadrupole radiation. If one considers, as usual, only dipole radiation, the transition would be strictly forbidden.

† I. S. Bowen, *Astrophys. Journ.* **67**, 1, (1928).

2. Only such transitions occur for which the *total angular momentum J changes by* $+1$, 0, or -1. In addition, the transition $J = 0 \rightarrow J = 0$ is forbidden. This rule is violated by disturbing strong magnetic fields and, also, in the case of quadrupole radiation in nebular spectra.

3. *Only one electron jumps at a time.* This is an approximate rule. It is most strictly obeyed when the levels of the configurations involved in the transition are most isolated from those of other configurations which might perturb them (Sec. 6). In general, the most important and strongest lines of a spectrum are due to such one-electron transitions.

4. When only *one electron* jumps, it *changes its* l by $+1$ or -1, and its n by an arbitrary amount. This rule is violated by disturbing electric fields. For extreme (j, j) coupling one can add that the electron changes its j by $+1$, 0, or -1.

5. *The resultant S remains unchanged* in a transition for Russell-Saunders coupling. This is an approximate rule. Transitions in which S changes, called *intercombinations,* occur more strongly the larger the deviations are from Russell-Saunders coupling, that is, the larger the multiplet separations are compared to the distances between multiplets of the same configurations. Intercombinations between singlets and triplets are unknown in helium, weak in magnesium, and they increase in intensity as one goes down any column in the Periodic Table. In mercury some of them are very strong lines.

6. *The resultant L in Russell-Saunders coupling changes by* $+1$, 0, -1, by preference. However, larger changes in L are not infrequent in complicated spectra.

7. In complicated spectra the *strongest lines* will arise from *transitions between states built upon the same state of the ion.* This is a result of Rule 3, which stated that only one electron changes its quantum numbers at a time.

8. *Transitions involving the change of more than one electron* will especially take place when the levels of neighboring configurations are near together and perturb each other. Quantum mechanical perturbation calculations carried to the first order show that up to this order a maximum of three electrons can jump.

9. When *three electrons jump* they change their n's arbitrarily, one changes its l by $+1$ or -1, the others by δ and ϵ, $\delta + \epsilon$ being even. The most probable values for δ and ϵ are 0, $+1$,

and -1. Such a transition, although not at all improbable *a priori*, has not yet been observed, since it requires the presence of a state with three electrons excited.

10. When *two electrons jump*, one changes its l by $\delta \pm 1$, the other by ϵ, $\delta + \epsilon$ being even. The n's can change arbitrarily. The most probable values for δ and ϵ are $+1, 0, -1$. In extreme (j, j) coupling we find that one j changes by $+1, 0, -1$, the other one by $0, \pm 1, \pm 2$; the latter occurs for the electron of which l changes by an even amount.

15. Intensity Rules.—It is not possible to give intensity rules which are generally valid. One can only say that the strongest lines will practically always be those which obey the above selection and transition rules. Among these lines the ones which are transitions between levels with large J values will often be stronger than others between levels of the same configurations.

Detailed intensity formulas are known for extreme Russell-Saunders and also for (j, j) coupling.* However, the intensities are most sensitive to perturbations caused by neighboring levels, and large deviations from the formulas often occur even in the simplest one-electron spectra.†

16. Zeeman Effect.—A few words must be said about the Zeeman effect, which is an important and powerful aid in the analysis of spectra. An external magnetic field causes each energy level to be split up into $(2J + 1)$ sublevels. When the separation is small compared to the distance from other levels, which, in general, can be obtained by taking the field weak enough, these sublevels will be equidistant and lie symmetrically around the original position of the level without field. The distance between them is proportional to the field strength H. It is measured in Lorentz units, which contain H:

$$\text{Lorentz unit} = \frac{heH}{4\pi mc}\ \text{cm.}^{-1}$$

The distance between the sublevels expressed in this unit is denoted by g, the Landé g-factor, which is characteristic for the term under consideration. The g-factor represents the ratio of the magnetic to the mechanical moment of the state, the

* For the latter see J. Bartlett, *Phys. Rev.* **35**, 229 (1930).

† E. Fermi, *Zeits. f. Physik.* **59**, 680 (1930).

former expressed in Bohr magnetons, $\frac{he}{4\pi mc}$; the latter in units, $\frac{h}{2\pi}$.

The Zeeman effect of a spectral line nearly always gives immediate information about the J values and g values of initial and final term. It thus gives a check on the J values, and one can investigate whether one or more lines have the same initial or final state.* This explains its usefulness.

The following formula gives the g values for extreme Russell-Saunders coupling.

$$g = 1 + \frac{J(J+1) + S(S+1) - L(L+1)}{2J(J+1)} \tag{7}$$

They are rather insensitive against deviations from Russell-Saunders coupling,† and the measured Zeeman effect, therefore, often gives not only the J values but also the values of S and L for initial and final state.

Formulas can also be derived for extreme (j, j) coupling, but they are of little use. An important rule for intermediate coupling is the *g-sum rule.* For a given configuration the sum of the g values for all levels with a given J is always independent of the coupling. Thus, one can calculate this sum under the assumption of Russell-Saunders coupling and will find the same sum value in any intermediate coupling. When there is in a configuration only one level with a certain value of J, according to this rule its g value will always be the same.

This rule, however, loses its validity when different configurations perturb each other, as discussed in Sec. 8. In such a case the g sum rule cannot be used to determine which levels belong together in one configuration.

17. Hyperfine Structure.—Many spectral lines, which according to the theory described in the previous sections should be single, are known to possess a further structure, called *hyperfine structure.* It was soon recognized that this hyperfine structure

* It rarely occurs that in the same spectrum two levels have identical J and g values. In such a case it will be possible to distinguish between them by means of other characteristics.

† Most g values are between 0.5 and 1.5. This makes it necessary to measure them with great accuracy in order to distinguish between values close together. However, even rough Zeeman effect measurements are of great use to confirm and check a given analysis.

had to be ascribed to properties of the atomic nucleus and not to the surrounding electrons. At present two different origins of hyperfine structure have been shown to exist.

a. Isotope Shift.—In this case the term values of the spectra of different isotopes are slightly displaced from each other. The exact cause of this difference is not yet known with certainty. The spectra of these isotopes must be considered as arising from quite different atoms, each component of the hyperfine-structure pattern belonging to a particular isotope. The neon spectrum possesses this type of hyperfine structure.

b. Nuclear Magnetism.—Quite a different type of hyperfine structure occurs when the atomic nucleus itself has a mechanical and magnetic moment. This causes a hyperfine structure which is closely analogous to multiplet structure. The different components of the hyperfine patterns are all produced by the same atom.

The two cases of hyperfine structure can be distinguished by means of their Zeeman effect. In Case *a*, each line of the pattern shows its own Zeeman effect which is independent of that of the other lines. In Case *b*, the Zeeman effect of the different components is not independent; the pattern changes with the strength of the applied magnetic field and one observes a so-called Paschen-Back effect. At present, spectra are known in which the complicated hyperfine structure is due both to isotope effect and to nuclear magnetism. Cadmium is an example of this case.

TABLE V

Multiplet Structure			Hyperfine Structure
Spin moment	S	I	Nuclear moment
Orbital moment	L	J	Moment of surrounding electrons
Resultant of S and L	J	F	Resultant of I and J
Magnetic spin moment	$g(S)S$	$g(I)I$	Nuclear magnetic moment
Magnetic orbital moment	$g(L)L$	$g(J)J$	Magnetic moment of surrounding electrons
Resultant magnetic moment	$g(J)J$	$g(F)F$	Resultant magnetic moment

The theory of hyperfine structure caused by nuclear spin can at once be taken from the theory of multiplets. Interval rule, intensity formulas, Zeeman effect, selection rules, and all further

properties which are derived from the vector model are quite alike for both cases. All one must do is to substitute the quantities occurring in the theory of hyperfine structure into the formulas derived for multiplet structure according to Table V on page 20. It is to be remembered that $g(S) = 2$ and $g(L) = 1$; $g(J)$ is given by formula (7). Considering the derivation of $g(J)$ and making the substitutions prescribed in Table V, one finds the following formula* for $g(F)$:

$$g(F) = g(J)\frac{F(F+1) + J(J+1) - I(I+1)}{2F(F+1)} + g(I)\frac{F(F+1) + I(I+1) - J(J+1)}{2F(F+1)}$$

As $g(I)$ seems to be always of the order of 0.001, the second term can be neglected.

The spectrum of bismuth, for which the nuclear moment I is $4\frac{1}{2}$, is an interesting example of this type of hyperfine structure.

Formulas have been derived which relate the magnitude of the hyperfine structure of different levels of the same atom. However, many points concerning nuclear moments and the magnitude of hyperfine structure remain still unexplained and seem to be in contradiction with the present theory.

* This example is given to show that one has to look into the derivation of a formula if one wants to apply the substitutions of Table V. If one had made the substitutions at once in formula (7) the answer would have been incorrect.

TABLES OF ENERGY STATES

A I $\qquad Z = 18$

18 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ {}^1S_0$

First ionization potential = 15.69 volts

The classification given here is largely from the work of Meissner. Two sets of tables are given, the first containing only the low terms and the second all terms arranged in series. The absolute value of all terms is given with respect to the $3p^5\ {}^2P_{1\frac{1}{2}}$ of A II.

References

K. W. Meissner, *Zeits. f. Physik* **39**, 172 (1926). $3p^5\,mp$ and mf terms and the low ms terms; also classified and unclassified lines.

K. W. Meissner, *Zeits. f. Physik* **40**, 839 (1926). $4d$ terms and low $3p^6\ {}^1S$ terms; also classified and unclassified lines.

W. Gremmer, *Zeits. f. Physik* **50**, 716 (1928) extension of infra-red classification.

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Paschen notation	Configuration	Symbol	J	Term value
$1p_0$	$3p^6$	${}^1S$	0	127103.8
$1s_5$	$3p^5\ ({}^2P_{1\frac{1}{2}})\ 4s$	1°	2	*33967.70*
$1s_4$		2°	1	*33360.86*
$1s_3$	$3p^5\ ({}^2P_{\frac{1}{2}})\ 4s$	3°	0	*32557.79*
$1s_2$		4°	1	*31711.62*
$2p_{10}$	$3p^5\ ({}^2P_{1\frac{1}{2}})\ 4p$	1	1	23009.42
$2p_9$		2	3	21648.70
$2p_8$		3	2	21494.13
$2p_7$		4	1	21024.20
$2p_6$		5	2	20873.91
$2p_5$		6	0	20057.17
$2p_4$	$3p^5\ ({}^2P_{\frac{1}{2}})\ 4p$	7	1	19979.75
$2p_3$		8	2	19821.76
$2p_2$		9	1	19615.04
$2p_1$		10	0	18388.83

(*Concluded*)

Paschen notation	Configuration	Symbol	J	Term value
$3d_6$	$3p^5\ (^2P_{1\frac{1}{2}})\ 3d$	1°	0	—
$3d_5$		2°	1	*15285.8*
$3d_3$		3°	2	—
$3d_4'$		4°	4	*14362.0*
$3d_4$		5°	3	—
$3d_1''$		6°	2	—
$3d_1'$		7°	3	—
$3d_2$		8°	1	*12961.6*
$2s_5$	$3p^5\ (^2P_{1\frac{1}{2}})\ 5s$	1°	2	*13646.3*
$2s_4$		2°	1	*13468.4*
$2s_3$	$3p^5\ (^2P_{\frac{1}{2}})\ 5s$	3°	0	*12248.94*
$2s_2$		4°	1	*12138.4*
$3s_1''''$	$3p^5\ (^2P_{\frac{1}{2}})\ 3d$	9°	2	—
$3s_1''$		10°	2	—
$3s_1'''$		11°	3	—
$3s_1'$		12°	1	*11742.3*

SERIES

$3p^6\ ^1S_0$
127103.8

	$3p^5\ (^2P_{1\frac{1}{2}})\ ms$		$3p^5\ (^2P_{\frac{1}{2}})\ ms$	
	s_5	s_4	s_3	s_2
m	$1_2°$	$2_1°$	$3_0°$	$4_1°$
4	*33967.70*	*33360.86*	*32557.79*	*31711.62*
5	*13646.3*	*13468.4*	*12248.94*	*12138.4*
6	*7428.39*	*7351.29*	*6014.82*	*5950.13*
7	*4671.41*	*4632.09*	*3238.44*	*3229.21*
8	*3208.24*	*3229.21*	*1776.73*	*1758.19*
9	*2339.84*	*2328.75*	*908.49*	*899.88*
10	*1781.51*	*1779.56*		
11	*1402.07*	*1396.01*		
12	*1132.11*	*1127.17*		
13	*933.22*			
14	*782.70*			

SERIES (*Continued*)

$3p^5\ (^2P_{1\frac{1}{2}})\ mp$

m	p_{10} 1_1	p_9 2_3	p_8 3_2	p_7 4_1	p_6 5_2	p_5 6_0
4	23009.42	21648.70	21494.13	21024.20	20873.91	20057.17
5	10451.43	10168.70	10112.12	9960.10	9927.84	9548.47
6	6042.50	5944.94	5919.48	5854.19	5840.46	5641.13
7	3938.95	3905.65	3890.65	3856.43	3849.73	3726.30
8	2799.70	2762.38	2754.70	2735.10	2730.41	2672.00
9	2071.83	2057.31	2051.60	2038.79	2036.53	1988.81
10	1605.92	1591.58	1586.42	1579.91	1577.61	1549.49
11	1267.17			1258.13	1257.65	1222.38
12					999.76	1009.72
13						841.44

$3p^5\ (^2P_{\frac{1}{2}})\ mp$

m	p_4 7_1	p_3 8_2	p_2 9_1	p_1 10_0
4	19979.75	19821.76	19615.04	18388.83
5	8703.94	8642.38	8651.83	8240.51
6	4510.00	4476.24	4501.81	4320.86
7	2467.81	2452.93	2460.37	2361.52
8	1327.71	1319.48	1334.11	1279.98
9				587.23

$3p^5\ (^2P_{1\frac{1}{2}})\ md$

m	d_6 1_0°	d_5 2_1°	d_3 3_2°	d_4' 4_4°	d_4 5_3°	d_1'' 6_2°	d_1' 7_3°	d_2 8_1°
3	—	*15285.8*	—	*14362.0*	—	—	—	*12961.6*
4	*8399.40*	*8460.07*	*8204.85*	*8087.81*	*7898.59*	*7666.55*	—	*7263.70*
5	*5317.39*	*5178.63*	*5024.56*	*5075.38*	*4951.29*	*4829.28*	*4781.81*	*4597.22*
6	*3602.55*	*3643.51*	—	*3458.28*	*3337.54*	*3284.65*	*3279.03*	*3175.53*
7	*2584.77*	*2556.59*	*2507.57*	*2501.59*	*2461.97*	*2419.50*	*2396.35*	*2323.11*
8	*1948.52*	*1975.62*		*1891.62*	*1842.03*	*1820.18*	*1817.83*	*1779.56*
9	*1516.41*	*1498.39*		*1479.81*	*1459.46*	*1440.06*	*1430.78*	
10	*1215.82*	*1212.87*		*1188.97*			*1154.08*	
11	*996.85*			*975.99*			*948.33*	
12				*815.71*				

SERIES (*Concluded*)

$3p^5\ (^2P_{\frac{1}{2}})\ md$				
	s_1''''	s_1''	s_1'''	s_1'
m	$9_2°$	$10_2°$	$11_3°$	$12_1°$
3	—	*12896.4*	—	*11742.3*
4	*6510.60*	*6492.46*	*6357.99*	*6099.53*
5	*3605.97*	*3738.54*	*3554.04*	*3302.90*
6	*1998.09*	*2045.03*	*1961.50*	*1828.46*
7	*1058.32*	*1205.00*	*1021.95*	
8		*522.72*		

m	$3p^5\ (^2P_{1\frac{1}{2}})\ mf$				$3p^5\ (^2P_{\frac{1}{2}})\ mf$
	X 1_1	Y $2_{1,2}$	U $3_{4,3}$	W $4_{4,3}$	Z $5_{1,2}$
4	6922.91	6881.55	—	—	5456.96
5	4425.09	4403.25	4413.7	4390.7	2974.22
6	3070.31	3059.85	3063.9	3052.2	1628.26
7	2254.16	2246.15	2250.1	2242.2	
8	1725.03	1719.90	1722.3	1718.1	
9	1362.6	1358.49	1360.2		
10	1098.3				

A II $\qquad Z = 18$

17 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5\ {}^2P_{1\frac{1}{2}}$

First ionization potential = 27.72 volts

The classification of this spectrum has been given for the greater part by De Bruin. The position of the lowest state is obtained from far ultra-violet data and is therefore not as accurately known as the other terms. The lowest state is calculated to be 224721 cm.$^{-1}$ with respect to $3p^4\,{}^3P$ of A III.

References

T. L. de Bruin, *Zeits. f. Physik.* **61,** 307 (1930).

K. T. Compton, J. C. Boyce, and H. N. Russell, *Phys. Rev.* **32,** 179 (1928).

C. J. Bakker, T. L. de Bruin, and P. Zeeman, *Zeits. f. Physik.* **52,** 299 (1928) and **62,** 32 (1930). Zeeman effect.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p^5$	${}^2P^o$	$1\frac{1}{2}$	*0*	-1431
		$\frac{1}{2}$	*1431*	
$3s\ 3p^6$	${}^2S$	$\frac{1}{2}$	108730	
$3s^2\ 3p^4\ ({}^3P)\ 3d$	${}^4D$	$3\frac{1}{2}$	132293.72	-153.98
		$2\frac{1}{2}$	132447.70	-149.62
		$1\frac{1}{2}$	132597.32	-107.03
		$\frac{1}{2}$	132704.35	
$3p^4\ ({}^3P)\ 4s$	${}^4P$	$2\frac{1}{2}$	134208.12	-844.40
		$1\frac{1}{2}$	135052.52	-515.70
		$\frac{1}{2}$	135568.22	
$3p^4\ ({}^3P)\ 4s$	${}^2P$	$1\frac{1}{2}$	138210.12	-1014.74
		$\frac{1}{2}$	139224.86	
$3p^4\ ({}^3P)\ 3d$	${}^4F$	$4\frac{1}{2}$	142152.92	-530.59
		$3\frac{1}{2}$	142683.51	-390.62
		$2\frac{1}{2}$	143074.13	-263.85
		$1\frac{1}{2}$	143337.98	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^4\,(^3P)\,3d$	^2P	$\frac{1}{2}$	144676.50	958.91
		$1\frac{1}{2}$	145635.41	
$3p^4\,(^3P)\,3d$	^4P	$2\frac{1}{2}$	144460.74	−491.55
		$1\frac{1}{2}$	144952.29	−225.65
		$\frac{1}{2}$	145177.94	
$3p^4\,(^1D)\,4s$	^2D	$1\frac{1}{2}$	148586.64	222.35
		$2\frac{1}{2}$	148808.99	
$3p^4\,(^3P)\,3d$	^2F	$3\frac{1}{2}$	149460.24	653.89
		$2\frac{1}{2}$	150114.13	
$3p^4\,(^3P)\,3d$	^2D	$1\frac{1}{2}$	150441.42	612.43
		$2\frac{1}{2}$	151053.85	
$3p^4\,(^3P)\,4p$	$^4P^\circ$	$2\frac{1}{2}$	*155009.87*	−307.75
		$1\frac{1}{2}$	*155317.62*	−357.30
		$\frac{1}{2}$	*155674.92*	
$3p^4\,(^3P)\,4p$	$^4D^\circ$	$3\frac{1}{2}$	*157200.42*	−439.36
		$2\frac{1}{2}$	*157639.78*	−494.57
		$1\frac{1}{2}$	*158134.35*	−260.32
		$\frac{1}{2}$	*158394.67*	
$3p^4\,(^3P)\,4p$	$^2D^\circ$	$2\frac{1}{2}$	*158696.72*	−663.09
		$1\frac{1}{2}$	*159359.81*	
$3p^4\,(^3P)\,4p$	$^2P^\circ$	$\frac{1}{2}$	*159673.02*	532.96
		$1\frac{1}{2}$	*160205.98*	
$3p^4\,(^3P)\,4p$	$^4S^\circ$	$1\frac{1}{2}$	*161015.40*	
$3p^4\,(^3P)\,4p$	$^2S^\circ$	$\frac{1}{2}$	*161055.92*	
$3p^4\,(^1S)\,4s$	^2S	$\frac{1}{2}$	167274.16	
$3p^4\,(^1D)\,4p$	$^2F^\circ$	$2\frac{1}{2}$	*170367.38*	129.41
		$3\frac{1}{2}$	*170496.79*	
$3p^4\,(^1D)\,3d$	^2F	$3\frac{1}{2}$		
		$2\frac{1}{2}$	171076.29	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^4\,(^1D)\,4p$	$^2P^\circ$	$1\frac{1}{2}$	*172180.30*	−602.50
		$\frac{1}{2}$	*172782.80*	
$3p^4\,(^1D)\,3d$	^2D	$2\frac{1}{2}$	172301.92	−494.55
		$1\frac{1}{2}$	172796.47	
$3p^4\,(^1D)\,4p$	$^2D^\circ$	$1\frac{1}{2}$	*173314.28*	45.65
		$2\frac{1}{2}$	*173359.93*	
$3p^4\,(^1D)\,3d$	^2P	$1\frac{1}{2}$	174376.40	−424.67
		$\frac{1}{2}$	174811.07	
$3p^4\,(^3P)\,5s$	^4P	$2\frac{1}{2}$	181560.62	−627.76
		$1\frac{1}{2}$	182188.38	−729.14
		$\frac{1}{2}$	182917.52	
$3p^4\,(^3P)\,5s$	^2P	$1\frac{1}{2}$	183056.82	−824.00
		$\frac{1}{2}$	183880.82	
$3p^4\,(^3P)\,4d$	^4D	$3\frac{1}{2}$	183641.92	−121.80
		$2\frac{1}{2}$	183763.72	−188.61
		$1\frac{1}{2}$	183952.33	−206.29
		$\frac{1}{2}$	184158.62	
$3p^4\,(^1D)\,3d$	^2S	$\frac{1}{2}$	184059.60	
$3p^4\,(^3P)\,4d$	^4F	$4\frac{1}{2}$	185059.42	−531.55
		$3\frac{1}{2}$	185590.97	−449.59
		$2\frac{1}{2}$	186040.56	−266.33
		$1\frac{1}{2}$	186306.89	
$3p^4\,(^3P)\,4d$	^4P	$\frac{1}{2}$	186137.82	299.00
		$1\frac{1}{2}$	186436.82	420.60
		$2\frac{1}{2}$	186857.42	
$3p^4\,(^3P)\,4d$	^2F	$3\frac{1}{2}$	186782.62	−772.50
		$2\frac{1}{2}$	187555.12	
$3p^4\,(^1D)\,5s$	^2D	$2\frac{1}{2}$	186694.00	−22.64
		$1\frac{1}{2}$	186716.64	
$3p^4\,(^3P)\,5p$	$^4P^\circ$	$2\frac{1}{2}$	*189125.71*	−251.19
		$1\frac{1}{2}$	*189376.90*	−288.90
		$\frac{1}{2}$	*189665.80*	

ARGON II

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^4\,(^3P)\,4d$	^2P	$\frac{1}{2}$	189901.12	658.00
		$1\frac{1}{2}$	190559.12	
$3p^4\,(^3P)\,5p$	$^4D^\circ$	$3\frac{1}{2}$	*189951.50*	−383.07
		$2\frac{1}{2}$	*190334.57*	−405.01
		$1\frac{1}{2}$	*190739.58*	−489.98
		$\frac{1}{2}$	*191229.56*	
$3p^4\,(^3P)\,5p$	$^2P^\circ$	$1\frac{1}{2}$	*190072.34*	−89.96
		$\frac{1}{2}$	*190162.30*	
$3p^4\,(^3P)\,5p$	$^2D^\circ$	$2\frac{1}{2}$		
		$1\frac{1}{2}$	*190473.50*	
$3p^4\,(^3P)\,5p$	$^2S^\circ$	$\frac{1}{2}$	*191673.96*	
$3p^4\,(^1S)\,4p$	$^2P^\circ$	$1\frac{1}{2}$	*191940.66*	−358.93
		$\frac{1}{2}$	*192299.59*	
$3p^4\,(^3P)\,4d$	^2D	$2\frac{1}{2}$	192523.31	−155.12
		$\frac{1}{2}$	192678.43	
$3p^4\,(^1D)\,5p$	$^2F^\circ$	$2\frac{1}{2}$	*194827.87*	21.61
		$3\frac{1}{2}$	*194849.48*	
$3p^4\,(^1D)\,5p$	$^2P^\circ$	$1\frac{1}{2}$	*195727.54*	−329.00
		$\frac{1}{2}$	*196056.54*	
$3p^4\,(^1S)\,3d$?	^2D	$2\frac{1}{2}$	195831.11	−2.07
		$1\frac{1}{2}$	195833.18	
$3p^4\,(^1D)\,5p$	$^2D^\circ$	$1\frac{1}{2}$	*196588.22*	11.32
		$2\frac{1}{2}$	*196599.54*	
$3p^4\,(^1D)\,4d$	^2G	$3\frac{1}{2}$	198561.41	8.87
		$4\frac{1}{2}$	198570.28	
$3p^4\,(^3P)\,6s$	^4P	$2\frac{1}{2}$	198778.67	−325.75
		$1\frac{1}{2}$	199104.42	−972.24
		$\frac{1}{2}$	200076.66	
$3p^4\,(^1D)\,4d$	^2P	$\frac{1}{2}$	199413.06	535.40
		$1\frac{1}{2}$	199948.46	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^4\,(^1D)\,4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	199491.46 199646.08	154.62
$3p^4\,(^3P)\,6s$	^2P	$1\frac{1}{2}$ $\frac{1}{2}$	199998.15 200589.50	−591.35
$3p^4\,(^1D)\,4d$	^2F	$3\frac{1}{2}$ $2\frac{1}{2}$	200105.34 200201.20	−95.86
$3p^4\,(^3P)\,5d$	^2P	$1\frac{1}{2}$ $\frac{1}{2}$	204383.50 204481.31	−97.81
$3p^4\,(^3P)\,5d$	^2D	$2\frac{1}{2}$	204551.90	
$3p^4\,(^1D)\,4d$	^2S	$\frac{1}{2}$	205209.46	

A III

$Z = 18$

16 electrons

$1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^4\; {}^3P_2$

Hopfield and Dieke found the ${}^3P - {}^3P°$ combination in the far ultra-violet. The quintets are taken from a paper by Deb and Dutt and seem to be rather uncertain. No intercombinations have been found so the triplets and quintets are listed in separate tables.

References

J. J. Hopfield and G. H. Dieke, *Phys. Rev.* **27,** 638 (1926).
I. S. Bowen, *Phys. Rev.* **31,** 497 (1928).
S. C. Deb and A. K. Dutt, *Zeits. f. Physik* **67,** 138 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\, 3p^4$	${}^3P$	2	0	
				1111
		1	1111	
				−463
		0	1574	
$3s\, 3p^5$	${}^3P°$	2	*113794*	
				−1002
		1	*114796*	
				−528
		0	*115324*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^3\, ({}^4S)\, 4s$	${}^5S°$	2	*0*	
$3p^3\, ({}^4S)\, 3d$	${}^5D°$	4	*460*	
				−51
		3	*511*	
				−25
		2	*536*	
				−47
		1	*583*	
				−29
		0	*612*	
$3p^3\, ({}^4S)\, 4p$	${}^5P$	1	30191	
				86
		2	30277	
				147
		3	30424	
$3p^3\, ({}^4S)\, 5s$	${}^5S°$	2	*63482.5*	
$3p^3\, ({}^4S)\, 4d$	${}^5D°$	0	*71490*	
				7
		1	*71497*	
				22
		2	*71519*	
				86
		3	*71605*	
				68
		4	*71673*	

A IV $Z = 18$

15 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^3\;{}^4S_{1\frac{1}{2}}^{\circ}$

Boyce and Compton have identified three resonance lines in the far ultra-violet in the spectrum of A IV.

Reference

J. C. Boyce and K. T. Compton, *Proc. Nat. Acad. Sci.* **15**, 656 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^3$	${}^4S^{\circ}$	$1\frac{1}{2}$	0	
$3s\;3p^4$	${}^4P$	$2\frac{1}{2}$	117161	
				932
		$1\frac{1}{2}$	118093	
				513
		$\frac{1}{2}$	118607	

Ag I $\qquad Z = 47$

47 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s\; ^2S_{\frac{1}{2}}$

First ionization potential = 7.54 volts

This classification has been taken for the main part from Fowler and Paschen-Götze.

References

FUJIOKA and NAKAMURA, *Astrophys. Journ.* **65**, 201 (1927). *f, g, h* terms obtained from Stark effect.

H. A. BLAIR, *Phys. Rev.* **36**, 1531 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^{10}\,(^1S)\,5s$	^2S	$\frac{1}{2}$	61104.4	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*31552.1* *30631.5*	920.6
$6s$	^2S	$\frac{1}{2}$	18548.5	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*12808.2* *12604.8*	203.4
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	12360.0 12339.9	20.1
$7s$	^2S	$\frac{1}{2}$	9217.3	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*6900.4*	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	6899.8 6890.5	9.3
$8s$	^2S	$\frac{1}{2}$	5523.3	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	4404.1 4398.6	5.5

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^{10}\,(^1S)\,5f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*4394.8*	
$9s$	^2S	$\frac{1}{2}$	3680.5	
$8d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	3054.6 3050.9	3.7
$10s$	^2S	$\frac{1}{2}$	2626.7	
$9d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	2241.7 2239.9	1.8
$11s$	^2S	$\frac{1}{2}$	1968.0	
$10d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	1714.9 1713.8	1.1
$12s$	^2S	$\frac{1}{2}$	1524.8	
$11d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	1353.9 1353.4	0.4
$12d$	^2D	$1\frac{1}{2}$	1100.5	

Ag II $Z = 47$

46 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\ {}^1S_0$

First ionization potential = 21.9 volts

The classification of this spectrum has been given for the greater part by Shenstone. The lowest state has been located by White. The notation used here is similar to that used for A I; the multiplet notations are given in the last column.

The absolute value of the lowest state is 177164 cm.$^{-1}$ with respect to $4d^9\,{}^2D_{2\frac{1}{2}}$ of Ag III.

References

A. G. SHENSTONE, *Phys. Rev.* **31,** 317 (1928). Term table and list of classified lines.

J. C. MCLENNAN and A. B. MCLAY, *Proc. Roy. Soc. Can.* **22,** 1 (1928).

K. MAJUMDAR, *Indian Journ. Phys.* **2,** 257 (1928).

H. A. BLAIR, *Phys. Rev.* **36,** 173 (1930).

Configuration	Symbol	J	Term value	
$4d^{10}$	^1S	0	0.0	^1S
$4d^9\,(^2D_{2\frac{1}{2}})\,5s$	1	3	39163.9	^3D
	2	2	40741.0	^3D
$4d^9\,(^2D_{1\frac{1}{2}})\,5s$	3	1	43738.7	^3D
	4	2	46045.2	^1D
$4d^9\,(^2D)\,5p$	1°	2	*80172.2*	$^3P°$
	2°	3	*82167.1*	$^3F°$
	3°	1	*83620.9*	$^3P°$
	4°	4	*83665.2*	$^3F°$
	5°	2	*85196.3*	$^3D°$
	6°	0	*96138.0*	$^3P°$
	7°	3	*86456.3*	$^3D°$
	8°	2	*86883.7*	$^3F°$
	9°	3	*89130.3*	$^1F°$
	10°	1	*89891.0*	$^1P°$
	11°	1	*90330.5*	$^3D°$
	12°	2	*90883.4*	$^1D°$

(*Concluded*)

Configuration	Symbol	J	Term value	
$4d^9\,(^2D_{2\frac{1}{2}})\,6s$	1	3	120526.6	^3D
	2	2	120904.1	^3D
$4d^9\,(^2D_{1\frac{1}{2}})\,6s$	3	1	125119.4	^3D
	4	2	125397.8	^1D
$4d^9\,(^2D)\,5d$	1	1	125568.9	^3S
	2	5	126660.5	^3G
	3	4	126673.1	^3G
	4	2	126760.2	^3P
	5	1	126763.7	^3P
	6	3	127205.0	^3D
	7	3	127484.5	^3F
	8	2	127517.0	^3D
	9	4	127601.8	^3F
	10	0	128528.8	^3P
	11	1	130756.0	^1P
	12	3	131246.3	^3G
	13	1	131500.5	^3D
	14	4	131510.5	^1G
	15	2	131783.9	^1D
	16	2	132148.9	^3F
	17	3	132191.8	^1F
	18	0	134449.4	^1S

Al I $\qquad Z = 13$

13 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p\ ^2P_{\frac{1}{2}}$

First ionization potential = 5.96 volts

The classification of this spectrum can be found for the most part in Fowler and in Paschen-Götze. It is of interest to note that the doublet separation of the lowest ^2D state is unusually small compared with higher members of this series.

References

A. Fowler, "Report," p. 156.
H. Kayser and H. Konen, **7**, 48.
F. Paschen and R. Götze, p. 124.
I. S. Bowen, *Phys. Rev.* **26**, 160 (1925).
W. D. Lansing, *Phys. Rev.* **34**, 597 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*48280.88* *48168.87*	112.01
$4s$	^2S	$\frac{1}{2}$	22933.27	
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	15845.49 15844.15	1.34
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*15331.70* *15316.48*	15.22
$3s\ 3p^2$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	15504.5 15468.3	
$3s^2\ 5s$	^2S	$\frac{1}{2}$	10591.58	
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	9351.71 9347.22	4.49
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*8009.19* *8003.24*	5.95

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*6962.6*	
$6s$	^2S	$\frac{1}{2}$	6136.76	
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	6047.37 6043.31	4.06
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*4946.01* *4943.19*	2.82
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*4451.5*	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	4114.33 4112.09	2.24
$7s$	^2S	$\frac{1}{2}$	4007.67	
$7p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*3351.0*	
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*3089.0*	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	2935.96 2935.06	0.90
$8s$	^2S	$\frac{1}{2}$	2833.2	
$8d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	2187.09 2185.74	1.35
$9d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	1684.3	
$10d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	1336.9	
$11d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	1091.0	
$3s\,3p^2$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	−8362.0 −8447.0	85.0

Al II $Z = 13$

12 electrons $1s^2\,2s^2\,2p^6\,3s^2\,{}^1S_0$

First ionization potential = 18.74 volts

The classification of this spectrum has been given by Sawyer and Paschen. The $3s\,md\,{}^3D$ terms are inverted. Dr. Sawyer has kindly communicated the finding of the $3p\,4s\,{}^3P°$ and ${}^1P°$ terms. The lowest ${}^3F°$ and ${}^1F°$ terms show a hyperfine structure with the following frequency differences:

$3s\,4f\,{}^3F_2°$	$\Delta\nu = 0.254$
${}^3F_3°$	$\Delta\nu = 0.490$
${}^3F_4°$	$\Delta\nu = 0.100$
${}^1F_3°$	$\Delta\nu = 0.490$

The first term table contains low series members and irregular terms arising from two excited electrons. A complete list of the regular terms is given in the series tables.

References

F. Paschen, *Ann. d. Physik* **71,** 537 (1923).

R. A. Sawyer and F. Paschen, *Ann. d. Physik* **84,** 1 (1927). Complete term tables, list of classified lines, and few unclassified lines.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2$	${}^1S$	0	151860.4	
$3s\,3p$	${}^3P°$	0	*114468.4*	
				61.8
		1	*114406.6*	
				125.5
		2	*114281.1*	
$3s\,3p$	${}^1P°$	1	*92010.7*	
$3s\,3d$	${}^1D$	2	66381.4	
$3s\,4s$	${}^3S$	1	60589.2	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^2$	^3P	0	57775.9	
		1	57713.6	62.3
		2	57592.7	120.9
$3s\ 4s$	^1S	0	56512.0	
$3s\ 3d$	^3D	3	56313.6	
		2	56312.5	−1.1
		1	56311.6	−0.9
$3s\ 4p$	$^3P^\circ$	0	*46436.1*	
		1	*46422.0*	14.1
		2	*46392.7*	29.3
$3s\ 4p$	$^1P^\circ$	1	*44942.2*	
$3s\ 4d$	^1D	2	41772.9	
$3s\ 5s$	^3S	1	31770.6	
$3s\ 5s$	^1S	0	30495.2	
$3s\ 4d$	^3D	3	30380.1	
		2	30379.5	−0.6
		1	30379.2	−0.3
$3s\ 4f$	$^3F^\circ$	2	*28444.5*	
		3	*28442.4*	2.1
		4	*28439.6*	2.8
$3s\ 4f$	$^1F^\circ$	3	*28392.3*	
$3s\ 5d$	^1D	2	27068.4	
$3s\ 5p$	$^3P^\circ$	0	*26159.9*	
		1	*26154.2*	5.7
		2	*26141.4*	12.8
$3s\ 5p$	$^1P^\circ$	1	*25993.7*	
$3s\ 6s$	^1S	0	19648.0	

ALUMINUM II

(Concluded)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\ 5d$	^3D	3 2 1	19040.7 19040.5 —	−0.2
$3s\ 5f$	$^3F^\circ$	2 3 4	*18425.4* *18420.0* *18413.1*	5.4 6.9
$3s\ 5f$	$^1F^\circ$	3	*18177.0*	
$3s\ 5g$	^3G	5	17678.0 ?	
$3s\ 6f$	$^3F^\circ$	2 3 4	*13341.7* *13324.0* *13301.2*	17.7 22.8
$3s\ 6f$	$^1F^\circ$	3	*12617.5*	
$3s\ 6g$	^3G	5	12271.7	
$3s\ 7g$	^3G	5	9011.2	
$3p\ 4s$	$^3P^\circ$	0 1 2	*6086.5* *6027.8* *5901.0*	58.7 126.8
$3p\ 4s$	$^1P^\circ$	1	*5262.0*	

SERIES

$3s\ ms$		
m	$^3S_1$	$^1S_0$
3		151860.4
4	60589.2	56512.0
5	31770.6	30495.2
6	19648.0	19084.0
7	13363.7	13061.1
8	9680.6	9499.6
9	7336.1	7218.5
10	5751.6	5670.3
11	4631.4	4571.6
12	3807.9	3763.3
13	3186.7	3153.5
14		2680.6
15		2305.7
16		2003.8

$3s\ mp$				
m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	$^1P_1^\circ$
3	*114468.4*	*114406.6*	*114281.1*	*92010.7*
4	*46436.1*	*46422.0*	*46392.7*	*44942.2*
5	*26159.9*	*26154.2*	*26141.4*	*25993.7*
6	*16851.4*	*16848.3*	*16841.5*	*16943.1*
7			*11769.2*	*11943.7*
8			*8693.0 ?*	*8901.5*
9			*6675.0 ?*	*6921.3*
10			*5283.0 ?*	*5562.9*
11			*4288.0 ?*	*4591.6*
12				*3858.4*
13				*3281.0*
14				*2808.5*
15				*2425.6*
16				*2112.4*
17				*1852.8*

SERIES (*Continued*)

3s md				
m	$^3D_3$	$^3D_2$	$^3D_1$	$^1D_2$
3	56313.6	56312.5	56311.6	66381.4
4	30380.1	30379.5	30379.2	41772.9
5	19040.7	19040.5		27068.4
6	13048.5			17946.3
7	9497.6			12573.6
8	7221.5			9253.4
9	5675.4			7080.2
10	4577.6			5586.0
11	3770.4			4517.2
12				3727.7

3s mf				
m	$^3F_2^\circ$	$^3F_3^\circ$	$^3F_4^\circ$	$^1F_3^\circ$
4	*28444.5*	*28442.4*	*28439.6*	*28392.3*
5	*18425.5*	*18420.0*	*18413.1*	*18177.0 ?*
6	*13341.7*	*13324.0*	*13301.2*	*12617.5*
7	*10778.0*	*10752.9*	*10719.9*	*9258.8*
8	*8597.7*	*8590.6*	*8579.8*	*7078.5*
9	*6733.9*	*6731.5*	*6728.3*	*5583.9*
10	*5363.7*	*5362.6*	*5361.2*	*4516.2*
11	*4360.6*	*4360.2*	*4359.6*	*3727.8*
12	*3611.7*	*3611.3*	*3610.8*	*3128.8*
13			*3037.9*	*2661.2*
14			*2590.9*	*2291.8*
15			*2234.9*	*1994.2*
16			*1947.2*	*1750.7*
17			*1712.0 ?*	*1549.3*
18			*1516.9*	*1380.7*
19				*1238.2*
20				*1116.3*

SERIES (*Concluded*)

$3s\,mg$	
m	$^3G_5$
5	17678.0 ?
6	12271.7
7	9011.2
8	6895.7
9	5445.9
10	4409.4
11	3642.8
12	3060.0
13	2607.5

Al III $Z = 13$

11 electrons $1s^2\,2s^2\,2p^6\,3s\ ^2S_{\frac{1}{2}}$

Ionization potential = 28.31 volts

The classification of this spectrum has been given by Paschen. It is interesting to note that the ^2D terms are inverted.

References

F. Paschen, *Ann. d. Physik* **71**, 142 (1923). Term table and classified lines.

E. Ekefors, *Zeits. f. Physik* **51**, 471 (1928). $7s$ and $7p$ levels and lines additional to Paschen.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s$	^2S	$\frac{1}{2}$	229454.0	
$3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*175774.1* *175536.1*	238.0
$3d$	^2D	$2\frac{1}{2}$ $1\frac{1}{2}$	113499.0 113496.7	−2.3
$4s$	^2S	$\frac{1}{2}$	103291.4	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*85821.7* *85741.6*	80.1
$4d$	^2D	$2\frac{1}{2}$ $1\frac{1}{2}$	63668.7 63667.5	−1.2
$4f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*61841.9* *61841.6*	0.3
$5s$	^2S	$\frac{1}{2}$	58817.6	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*51023.5* *50984.4*	39.1
$5d$	^2D	$2\frac{1}{2}, 1\frac{1}{2}$	40578.5	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*39578.7* *39578.5*	0.2
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	39526.2	
$6s$	^2S	$\frac{1}{2}$	37980.0	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*33833.1* *33812.5*	20.6
$6d$	^2D	$2\frac{1}{2}, 1\frac{1}{2}$	28079.6	
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*27484.5*	
$6g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	27452.7	
$6h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*27446.7*	
$7s$	^2S	$\frac{1}{2}$	26549.2	
$7p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*24094.0*	
$7d$	^2D	$2\frac{1}{2}, 1\frac{1}{2}$	20573.6	
$7f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*20193.0*	
$7g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	20171.8	
$7h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*20166.5*	
$8d$	^2D	$2\frac{1}{2}, 1\frac{1}{2}$	15712.6	
$8f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*15461.9*	
$8g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	15443.3	
$8h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*15438.2*	
$9h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*12198.8*	

Al IV $\qquad Z = 13$

10 electrons $\qquad 1s^2\, 2s^2\, 2p^6\ {}^1S_0$

Edlén and Ericson have identified the pair of resonance lines of Al IV in the far ultra-violet.

Reference

B. Edlén and A. Ericson, *Comptes Rendus* **190**, 116 (1930).

Configuration	Symbol	J	Term value
$3p^6$	^1S	0	0
$3p^5\ (^2P_{1\frac{1}{2}})\ 4s$	$^3P^\circ$	1	*618498*
$3p^5\ (^2P_{\frac{1}{2}})\ 4s$	$^1P^\circ$	1	*624723*

Al V $Z = 13$

9 electrons $1s^2\ 2s^2\ 2p^5\ {}^2P_{1\frac{1}{2}}^{\circ}$

By use of the irregular doublet law Edlén and Ericson have found a doublet in the far ultra-violet belonging to the spectrum of four-times ionized aluminum.

Reference

B. Edlén and A. Ericson, *Comptes Rendus* **190,** 173 (1930).

Configuration	Symbol	J	Term value
$2s^2\ 2p^5$	$^2P^{\circ}$	$1\frac{1}{2}$	*0*
		$\frac{1}{2}$	*3420*
$2s\ 2p^6$	^2S	$\frac{1}{2}$	358783

Al VI $Z = 13$

8 electrons $1s^2\,2s^2\,2p^4\;{}^3P_2$

Edlén and Ericson have found the PP° group in the far ultraviolet at about 300 Å.

Reference

B. Edlén and A. Ericson, *Comptes Rendus* **190**, 173 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^4$	${}^3P$	2	0	
				−2745
		1	2745	
				−1074
		0	3819	
$2s\,2p^5$	${}^3P^\circ$	2	*323010*	
				−2446
		1	*325456*	
				−1359
		0	*326815*	

As I $\qquad Z = 33$

33 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^3\;{}^4S_{1\frac{1}{2}}^{\circ}$

First ionization potential = 10 volts

The arc spectrum of arsenic has been analyzed recently by Meggers and De Bruin and by Rao. Rao has investigated the violet and ultra-violet and Meggers the visible and near infra-red. They agree only for the $4p^3$ and $4p^2\,5s$ terms. The other terms have been numbered and the source denoted by *M* or *R*. The classification which they have suggested is given in the last column. Unfortunately many terms are based on only one combination.

References

A. E. Ruark, F. L. Mohler, P. D. Foote, and R. L. Chenault, *Bur. Stand. Sci. Papers* **19,** 477 (1924).

S. L. Malurkar, *Proc. Camb. Phil. Soc.* **24,** 85 (1928).

J. C. McLennan and A. B. McLay, *Proc. Roy. Soc. Can.* **21,** 75 (1927).

W. F. Meggers and T. L. de Bruin, *Bur. Stand. Journ. Res.* **3,** 765 (1929).

K. R. Rao, *Proc. Roy. Soc.* **A125,** 238 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$	Remarks
$4p^3$	${}^4S^{\circ}$	$1\frac{1}{2}$	*0.0*		
$4p^3$	${}^2D^{\circ}$	$1\frac{1}{2}$	*10591.46*	322.23	
		$2\frac{1}{2}$	*10913.69*		
$4p^3$	${}^2P^{\circ}$	$\frac{1}{2}$	*18185.26*	461.33	
		$1\frac{1}{2}$	*18646.59*		
$4p^2\,(^3P)\,5s$	${}^4P$	$\frac{1}{2}$	50692.72	916.48	
		$1\frac{1}{2}$	51609.20	1287.69	
		$2\frac{1}{2}$	52896.89		
$4p^2\,(^3P)\,5s$	${}^2P$	$\frac{1}{2}$	53134.44	1469.79	
		$1\frac{1}{2}$	54604.23		
$4p^2\,(^1D)\,5s$	${}^2D$	$2\frac{1}{2}$	60814.13	−19.70	
		$1\frac{1}{2}$	60833.83		
—	1°	$\frac{1}{2}$	*60858.99*	*M*	$4p^2\,5p\;{}^4P$
	2°	$1\frac{1}{2}$	*61582.55*	*M*	$4p^2\,5p\;{}^4P$
	3	$3\frac{1}{2}$	61961.97	*M*	$4p^2\,4d\;{}^4F$

ARSENIC I

(*Concluded*)

Configuration	Symbol	J	Term value	Remarks
—	4	2½	62749.91	M $4p^2\,4d\ ^4F$ R $4s\ 4p^4\ ^4P$
	5°	2½	*62971.70*	M $4p^2\,5p\ ^4P$
	6°	½	*62025.24*	M $4p^2\,5p\ ^4D$
	7°	1½	*62396.86*	M $4p^2\,5p\ ^4D$
	8°	1½	*62553.34*	M $4p^2\,5p\ ^2D$
	9°	2½	*63281.83*	M $4p^2\,5p\ ^4D$
	10	1½	63502.62	M $4p^2\,4d\ ^4F$ R $4s\ 4p^4\ ^4P$
	11°	1½	*63645.92*	M $4p^2\,5p\ ^4S$
	12	½	63980.62	M $4p^2\,4d\ ^4D$ R $4s\ 4p^4\ ^4P$
	13	1½	64121.22	M $4p^2\,4d\ ^4D$
	14°	2½	*64168.15*	M $4p^2\,5p\ ^2D$
	15°	½	*64251.06*	M $4p^2\,5p\ ^2P$
	16°	1½	*64322.68*	M $4p^2\,5p\ ^2P$
	17	2½	64341.31	M $4p^2\,4d\ ^4D$
	18	2½	64339.3	R $4p^2\,4d\ ^4D$
	19°	3½	*64448.85*	M $4p^2\,5p\ ^4D$
	20	1½, 2½	64810.23	M $4p^2\,5s\ ^2S$ R $4s\ 4p^4\ ^2D$
	21	3½	64840	M $4p^2\,4d\ ^4D$
	22°	½	*65100.26*	M $4p^2\,5p\ ^2S$
	23	½ ?	65496.17	M $4p^2\,4d\ ^4P$?
	24	?	66277.1	R $4p^2\,4d\ ^2F$
	25	3½	66297	M $4p^2\,4d\ ^2F$
	26	½, 1½ ?	66482.96	M $4p^2\,4d\ ^4P$ R $4p^2\,4d\ ^4D$
	27	½	66515.7	R $4p^2\,4d\ ^4D$
	28	1½	66586.24	M $4p^2\,4d\ ^4P$ R $4s\ 4p^4\ ^2S$
	29	2½	66720.5	R $4p^2\,4d\ ^4D$
	30	3½	66780.4	R $4p^2\,4d\ ^4D$
	31	2½	67006.62	M $4p^2\,4d\ ^4P$
	32	2½	67468.76	M $4p^2\,4d\ ^2F$
	33	½	67919.26	MR $4p^2\,4d\ ^2P$
	34	1½	68299.73	RM $4p^2\,4d\ ^2D$
	35	2½	68401.97	MR $4p^2\,4d\ ^2D$
	36	1½ ?	69693.6	R
	37	1½ ?	72119.6	R
	38	½	72513.4	R $4p^2\,4d\ ^2P$
	39	1½	72773.6	R $4p^2\,4d\ ^2P$
	40°	?	*73243.96*	M
	41	½, 1½ ?	73628.1	R
	42	½, 1½ ?	74597.3	R

As III $\quad Z = 33$

31 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p\ ^2P_{\frac{1}{2}}$

First ionization potential = 28.0 volts

In this spectrum doublets and quartets have been found but no intercombinations between them. The absolute value of the lowest doublet state is 220221 cm.$^{-1}$ according to Pathabhiramiah and Rao.

References

R. J. Lang, *Phys. Rev.* **32,** 737 (1928).
P. Pathabhiramiah and A. S. Rao, *Indian Journ. Phys.* **3,** 441 (1928).
A. S. Rao and A. L. Narayan, *Zeits. f. Physik* **57,** 865 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2 4p$	$^2P^\circ$	$\frac{1}{2}$	*0*	2946
		$1\frac{1}{2}$	*2946*	
—	1	$\frac{1}{2}, 1\frac{1}{2}$	99940	
$4s^2\, 5s$	^2S	$\frac{1}{2}$	102604	
$4s^2\, 4d$	^2D	$1\frac{1}{2}$	109782	356
		$2\frac{1}{2}$	110138	
$4s\ \ 4p^2$	^2P	$\frac{1}{2}$	113941	1487
		$1\frac{1}{2}$	115428	
$4s^2\, 5p$	$^2P^\circ$	$\frac{1}{2}$	*127368*	724
		$1\frac{1}{2}$	*128092*	
$4s^2\, 4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*156246*	
$4s^2\, 6s$	^2S	$\frac{1}{2}$	158076	
$4s^2\, 5d$	^2D	$1\frac{1}{2}$	161532	86
		$2\frac{1}{2}$	161618	

ARSENIC III

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\ 6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*167925* *168227*	302
$4s^2\ 5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*179803*	
$4s^2\ 4g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	180621	
$4s^2\ 6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	185212 185243	31
$4s^2\ 7p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*189370* *189514*	
$4s^2\ 7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	196295 196313	18
$4s^2\ 8s$	^2S	$\frac{1}{2}$	196979	

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s\ 4p\ 5s$	$^4P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*0* *1062* *3195*	1062 2133
$4s\ 4p\ 5p$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	22240 22672 23465 24894	432 793 1429
$4s\ 4p\ 5p$	^4S	$1\frac{1}{2}$	26723	
$4s\ 4p\ 5p$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	27792 28529 29853	737 1324
$4s\ 4p\ 5d$	$^4F^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	*42114* *42238* *42605* *43455*	124 367 850
$4s\ 5p\ 5d$	$^4D^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	*43124* *43491* *44240* *45523*	367 749 1283

As IV $Z = 33$

30 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\ {}^1S_0$

The classification of this spectrum has been given by Sawyer and Humphreys and is based on observations in the far ultraviolet. The normal state has not been found. The absolute value of the $4s\,4p\ {}^3P_0$ state has been estimated to be 343400 cm.$^{-1}$

References

R. A. SAWYER and C. J. HUMPHREYS, *Phys. Rev.* **32,** 583 (1928).
K. R. RAO, *Nature* **123,** 244 (1929). $4s\,5p$ terms.
P. QUENEY, *Journ. de Physique* **10,** 448 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s\,4p$	${}^3P^\circ$	0	*0*	
		1	*1150*	1150
		2	*3680*	2530
$4p^2$	${}^3P$	0	104123	
		1	105659	1536
		2	108585	2926
$4s\,4d$	${}^3D$	1	134785	
		2	134915	130
		3	135121	206
$4s\,5s$	${}^3S$	1	144313	
$4s\,5p$	${}^3P^\circ$	0	*175390*	
		1	*175652*	262
		2	*176468*	816

As V $Z = 33$

29 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 62.5 volts

This spectrum has been classified by Sawyer and Humphreys on the basis of ultra-violet observations. The absolute value of the lowest state is 505136 cm.$^{-1}$, and has been obtained by extrapolation of values of $\sqrt{\nu/R}$ from homologous spectra and by series formulas.

Reference

R. A. Sawyer and C. J. Humphreys, *Phys. Rev.* **32**, 583 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s$	^2S	$\frac{1}{2}$	0	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*97135* *101245*	4110
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	236897 ? 237342 ?	445
$5s$	^2S	$\frac{1}{2}$	263596	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*331987*	

Au I $\qquad Z = 79$

79 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10} 4s^2 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6 5d^{10}\ 6s\ ^2S_{\frac{1}{2}}$

First ionization potential = 9.2 volts

The classification is given according to McLennan and McLay. The absolute value of the lowest state is estimated to be 74461.cm.$^{-1}$ with respect to the $5d^{10}\ ^1S_0$ of Au II.

Some of the terms are based upon only a few combinations and the assignments cannot be given without ambiguity. The multiplet assignments made by McLennan and McLay to the levels of the $5d^9\ 6s\ 6p$ configuration are given in the last column.

McLennan and McLay assign the five highest terms to the configuration $6d^9\ 6s\ 6d$.

References

J. C. McLennan and A. B. McLay, *Proc. Roy. Soc.* **112**, 95 (1926).

Y. Fujioka and S. Nakamura, *Astrophys. Journ.* **65**, 201 (1927). f terms extrapolated by means of Stark effect.

A. S. M. Symons and J. Daley, *Proc. London Phys. Soc.* **41**, 432 (1929). Zeeman effect.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d^{10}\ 6s$	^2S	$\frac{1}{2}$	0.0	
$5d^9\ 6s^2$	^2D	$2\frac{1}{2}$	9160.8	-12274.0
		$1\frac{1}{2}$	21434.8	
$5d^{10}\ 6p$	$^2P^\circ$	$\frac{1}{2}$	*37358.6*	3815.6
		$1\frac{1}{2}$	*41174.2*	

GOLD I

(*Concluded*)

Configuration	Symbol	J	Term value	Remarks	$\Delta\nu$
$5d^9\,6s\,6p$	$1°$	$3\frac{1}{2}$	*42163.0*	$^2F_{3\frac{1}{2}}$	
	$2°$	$3\frac{1}{2}$	*45536.7*	$^4F_{3\frac{1}{2}}$	
	$3°$	$2\frac{1}{2}$	*46174.5*	$^2D_{2\frac{1}{2}}$	
	$4°$	$1\frac{1}{2}$	*47007.0*	$^2D_{1\frac{1}{2}}$	
	$5°$	$3\frac{1}{2}$	*51028.4*	$^4D_{3\frac{1}{2}}$	
	$6°$	$1\frac{1}{2}$	*51231.0*	$^2P_{1\frac{1}{2}}$	
	$7°$	$2\frac{1}{2}$	*51653.1*	$^2F_{2\frac{1}{2}}$	
	$8°$	$\frac{1}{2}$	*53208.3*	$^2P_{\frac{1}{2}}$	
	$9°$	$1\frac{1}{2}$ or $2\frac{1}{2}$	*56105.2*		
	$10°$	$1\frac{1}{2}$ or $2\frac{1}{2}$	*58616.2*		
	$11°$	$1\frac{1}{2}$ or $2\frac{1}{2}$	*61255.4*		
	$12°$	$1\frac{1}{2}$ or $2\frac{1}{2}$	*63712.9*		
$5d^{10}$ $7s$	^2S	$\frac{1}{2}$	54484.8		
$7p$	$^2P°$	$\frac{1}{2}$	*60032.5*		695.7
		$1\frac{1}{2}$	*60728.2*		
$6d$	^2D	$1\frac{1}{2}$	61951.5		82.4
		$2\frac{1}{2}$	62033.9		
$8s$	^2S	$\frac{1}{2}$	64742.4		
$7d$	^2D	$1\frac{1}{2}$	67468.1		42.8
		$2\frac{1}{2}$	67510.9		
$5d^9\,6s\,6d$?	13	$3\frac{1}{2}$	67810.8		
	14	$2\frac{1}{2}$	68704.6		
	15	$1\frac{1}{2}$	70652.7		
	16	$4\frac{1}{2}$	76731.5		
	17	$4\frac{1}{2}$	76829.2		

78 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ {}^1S_0$

The classification has been given by McLennan and McLay. The normal state, $5d^{10}\ {}^1S_0$, has not been found. The absolute value of the $5d^9 6s\ 1_3$, $({}^3D_3)$ can be estimated to be 154000 cm.$^{-1}$ with respect to the $5d^9\ {}^2D_{2\frac{1}{2}}$ of Au III. Since the Russell-Saunders coupling does not hold for Au II, the terms have been numbered and the probable multiplet notation assigned by McLennan is given in the last column.

References

J. C. McLennan and A. B. McLay, *Proc. Roy. Soc. Can.* **22**, 103 (1928).
J. E. Mack, *Phys. Rev.* **34**, 17 (1929).

Configuration	Symbol	J	Term value	Remarks
$5d^9\ ({}^2D_{2\frac{1}{2}})\ 6s$	1	3	0.0	${}^3D$
	2	2	2601.5	${}^3D$
$5d^9\ ({}^2D_{1\frac{1}{2}})\ 6s$	3	1	12726.7	${}^3D$
	4	2	14582.0	${}^1D$
$5d^9\ ({}^2D)\ 6p$	1°	2	*48014.5*	${}^3P^\circ$
	2°	3	*49964.2*	${}^3F^\circ$
	3°	4	*57455.7*	${}^3F^\circ$
	4°	2	*58138.8*	${}^3D^\circ$
	5°	1	*58364.5*	${}^3P^\circ$
	6°	3	*59752.1*	${}^3D^\circ$
	7°	2	*61620.5*	${}^3F^\circ$
	8°	1	*66620.2*	${}^1P^\circ$
	9°	0	*67574.5*	${}^3P^\circ$
	10°	3	*70660.8*	${}^1F^\circ$
	11°	1	*70668.0*	${}^3D^\circ$
	12°	2	*71526.0*	${}^1D^\circ$
$5d^9\ ({}^2D_{2\frac{1}{2}})\ 7s$	1	3	93131.5	${}^3D$
	2	2	93589.8	${}^3D$

(*Concluded*)

Configuration	Symbol	J	Term value	Remarks
$5d^9\ (^2D_{1\frac{1}{2}})\ 7s$	3	1	105781.2	^3D
	4	2	106077.0	^1D
$5d^9\ (^2D)\quad 6d$	1	1	101008.8	^3S
	2	4	101904.8	^3G
	3	5	101952.2	^3G
	4	2	102023.9	^3P
	5	1	102256.4	^3P
	6	3	102470.4	^3D
	7	3	102941.8	^3F
	8	2	102988.0	^3D
	9	4	103126.6	^3F
	10	0	103212.6	^1S

B I $\qquad Z = 5$

5 electrons $\qquad 1s^2\ 2s^2\ 2p\ ^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 8.28 volts

The classification of this spectrum has been made by Bowen and by Sawyer. The absolute value of the lowest term, $2p\ ^2P_{\frac{1}{2}}$, is given by Sawyer as 67082 cm.$^{-1}$.

References

R. A. Sawyer, *Naturwiss.* **15**, 765 (1927).
I. S. Bowen, *Phys. Rev.* **29**, 231 (1927).
F. R. Smith and R. A. Sawyer, *Journ. Opt. Soc. Am.* **14**, 287 (1927).

Configuration	Symbol	J	Term value
$2s^2\ 2p$	$^2P^{\circ}$	$\frac{1}{2}$	*0*
		$1\frac{1}{2}$	*15*
$3s$	^2S	$\frac{1}{2}$	40039
$2s\ 2p^2$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	47856
$2s^2\ 3d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	54767
$4s$	^2S	$\frac{1}{2}$	55007
$4d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	59998
$5d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	62488

B II $Z = 5$

4 electrons $1s^2\,2s^2\ {}^1S_0$

First ionization potential = 25.0 volts

These terms were originally taken from unpublished work of Bowen. They have been considerably extended from unpublished work of Edlén. The absolute values of the singlets, although given in the tables, are not as well founded as the triplets. Intercombinations have not been observed.

References

I. S. Bowen and R. A. Millikan, *Phys. Rev.* **26**, 310 (1925).
I. S. Bowen, unpublished material.
B. Edlén, unpublished material.

Configuration	Symbol	J	Term value
$2s^2$	^1S	0	202646.0
$2s\ 2p$	$^1P^\circ$	1	*129249.3*
$2p^2$	^1D	2	100283.9
$2p^2$	^1S	0	74984.0
$2s\ 3s$	^1S	0	66414.3
$2s\ 3p$	$^1P^\circ$	1	*58544.0*
$2s\ 3d$	^1D	2	47959.1
$2s\ 4s$	^1S	0	34711.8
$2s\ 4f$	$^1F^\circ$	3	*27724.5*
$2s\ 4d$	^1D	2	27100.0
$2p\ 3s$	$^1P^\circ$	1	*14990.2*
$2p\ 3p$	^1D	2	13519.4
$2p\ 3d$	$^1D^\circ$	2	*4925.0*

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p$	$^3P^\circ$	0	*165561.4*	
		1	*165555.0*	6.4
		2	*165538.6*	16.4
$2p^2$	^3P	0	103984.7	
		1	103976.3	8.4
		2	103962.3	14.0
$2s\ 3s$	^3S	1	73122.1	
$2s\ 3p$	$^3P^\circ$	0, 1	*58900.0*	
		2	*58896.3*	3.7
$2s\ 3d$	^3D	1, 2, 3	52246.0	
$2s\ 4s$	^3S	1	36545.3	
$2s\ 4p$	$^3P^\circ$	0, 1, 2	*31350.3*	
$2s\ 4d$	^3D	1, 2, 3	28817.1	
$2s\ 4f$	$^3F^\circ$	2, 3, 4	*27992.5*	
$2s\ 5s$	^3S	1	21993.2	
$2p\ 3s$	$^3P^\circ$	0	*21249.8*	
		1	*21240.0*	9.8
		2	*21219.1*	20.9
$2s\ 5p$	$^3P^\circ$	0, 1, 2	*19561.3*	
$2s\ 5d$	^3D	1, 2, 3	18256.6	
$2s\ 5f$	$^3F^\circ$	2, 3, 4	*17986.8*	
$2s\ 6f$	$^3F^\circ$	2, 3, 4	*12426.0*	
$2p\ 3d$	$^3D^\circ$	1, 2, 3	*2410.4*	

B III $Z = 5$

3 electrons $1s^2\ 2s\ ^2S_{\frac{1}{2}}$

First ionization potential = 37.75 volts

These terms are from unpublished material of B. Edlén and contain several new high-series members.

References

I. S. Bowen and R. A. Millikan, *Proc. Nat. Acad. Sci.* **10,** 199 (1924).
F. R. Smith and R. A. Sawyer, *Journ. Opt. Soc. Am.* **14,** 287 (1927).
A. Ericson and B. Edlén, *Zeits. f. Physik* **59,** 656 (1929). Far ultra-violet.
B. Edlén, unpublished material.

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s$	^2S	$\frac{1}{2}$	305931.1	
$2p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*257572.6* *257538.5*	34.1
$3s$	^2S	$\frac{1}{2}$	125734.6	
$3p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*112981.9* *112971.7*	10.2
$3d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	109861.0	
$4s$	^2S	$\frac{1}{2}$	68235.6	
$4p$	$^2P^{\circ}$	$\frac{1}{2}, 1\frac{1}{2}$	*63100.1*	
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	61794.7	
$4f$	$^2F^{\circ}$	$2\frac{1}{2}, 3\frac{1}{2}$	*61731.9*	
$5s$	^2S	$\frac{1}{2}$	42774.9	
$5p$	$^2P^{\circ}$	$\frac{1}{2}, 1\frac{1}{2}$	*40212.1*	

(*Concluded*)

Configuration	Symbol	J	Term value	
$5d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	39541.8	
$5f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*39516.6*	
$5g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	39503.9	
$6f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*27441.4*	
$6g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	27433.6	

B IV $Z = 5$

2 electrons $1s^2\ {}^1S_0$

Ionization potential = 258.1 ± 0.2 volts

Edlén located two singlet combinations in this spectrum. He found the absolute value of the lowest state to be 2091500 ± 1400 cm.$^{-1}$ by extrapolating from other helium-like spectra.

Reference

B. Edlén, *Nature* **127**, 405 (1931).

Configuration	Symbol	J	Term value
$1s^2$	${}^1S$	0	0
$1s\ 2p$	${}^1P^\circ$	1	*1658200*
$1s\ 3p$	${}^1P^\circ$	1	*1898100*

·B V $\qquad\qquad Z = 5$

1 electron $\qquad\qquad 1s\ ^2S_{\frac{1}{2}}$

Ionization potential = 338.5 volts

For a more detailed discussion compare H I. The terms of this spectrum are given by

$$\frac{E(n, l, j)}{hc} = \frac{R_B \times 25}{n^2} + \frac{5.822 \times 625}{n^3}\left(\frac{3}{4n} - \frac{1}{j + \frac{1}{2}}\right)$$

where

$$R_B = \frac{R}{\left(1 + \frac{m}{M_B}\right)} = 109731.4 .$$

The first line of the Lyman series has been found by Edlén.

Reference

B. Edlén, *Nature* **127**, 405 (1931).

Ba I $Z = 56$

56 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ 6s^2\ {}^1S_0$

First ionization potential = 5.19 volts

These terms are taken from Paschen-Götze, Fowler, and the work of Russell and Saunders.

The absolute values of all terms are given with respect to $6s\ {}^2S_{\frac{1}{2}}$ of Ba II. The first table contains *all* levels, the other tables only those based upon $6s\ {}^2S_{\frac{1}{2}}$ of Ba II. The older notation used by Russell and Saunders is given in the first column.

References

H. N. Russell and F. A. Saunders, *Astrophys. Journ.* **61**, 38 (1925).
G. Wentzel, *Zeits. f. Physik* **34**, 730 (1925).

	Configuration	Symbol	J	Term value	$\Delta\nu$
$1S$	$6s^2$	^1S	0	42029.4	
$1d_3$	$6s\ 5d$	^3D	1	32995.6	
					181.5
$1d_2$			2	32814.1	
					381.1
$1d_1$			3	32433.0	
$1D$	$6s\ 5d$	^1D	2	30634.1	
$1p_3$	$6s\ 6p$	$^3P^\circ$	0	*29763.3*	
					370.5
$1p_2$			1	*29392.8*	
					878.0
$1p_1$			2	*28514.8*	
$1P$	$6s\ 6p$	$^1P^\circ$	1	*23969.2*	
q_{11}	—	1°	—	*20124.0*	
$1f_3''$	$5d\ 6p$	$^3F^\circ$	2	*19964.8*	
					882.7
$1f_2''$			3	*19082.1*	
					709.5
$1f_1''$			4	*18372.6*	
x	—	2°	—	*18955.2*	
$1p_3'$	$5d^2$	^3P	0	18820.3	
					271.0
$1p_2'$			1	18549.3	
					438.8
$1p_1'$			2	18110.5	

(*Continued*)

	Configuration	Symbol	J	Term value	$\Delta\nu$
w	—	$3°$	2 or 3	*18457.5*	
q_4	—	4	1	18032.0	
$1d_3'$	$5d\ 6p$	$^3D°$	1	*17837.6*	339.5
$1d_2'$			2	*17498.1*	448.3
$1d_1'$			3	*17049.8*	
$1p_3''$	$5d\ 6p$	$^3P°$	0	*16387.5*	62.0
$1p_2''$			1	*16325.5*	252.4
$1p_1''$			2	*16073.1*	
$2S$	$6s\ 7s$	^1S	0	16399.4	
$1s$	$6s\ 7s$	^3S	1	15869.3	
Y	—	$5°$	2 or 3	*15213.4*	
$2D$	$6s\ 6d$	^1D	2	13800.4	
	—	6	3 ?	13475.2	
$2d_3$	$6s\ 6d$	^3D	1	11333.9	54.9
$2d_2$			2	11279.0	67.4
$2d_1$			3	11211.6	
$2p_3$	$6s\ 7p$	$^3P°$	0	*11286.4*	72.2
$2p_2$			1	*11214.2*	171.9
$2p_1$			2	*11042.3*	
	—	7	2 ?	10018.0	
X		8	1 or 2	9929.0	
$2P$	$6s\ 7p$	$^1P°$	1	*9482.2*	
$2s$	$6s\ 8s$	^3S	1	8124.3	
$3D$	$6s\ 7d$	^1D	2	7931.0	
$2p_3'$	$6p^2$	^3P	0	7535.6	329.7
$2p_2'$			1	7205.9	793.1
$2p_1'$			2	6412.8	

(*Continued*)

	Configuration	Symbol	J	Term value	$\Delta\nu$
$3f_3$	$6s\ 4f$	$^3F^\circ$	2	*7426.8*	16.0
$3f_2$			3	*7412.8*	14.2
$3f_1$			4	*7398.6*	
q_{10}	—	9°	1 or 2 or 3	*7293.4*	
q_2		10	1 or 2	7240.2	
q_3		11	1	7198.2	
q_1		12	1 or 2	6685.1	
$3d_3$	$6s\ 7d$	^3D	1	6320.1	52.8
$3d_2$			2	6267.3	23.0
$3d_1$			3	6244.3	
$3p_3$	$6s\ 8p$	$^3P^\circ$	0	*6186.9*	49.6
$3p_2$			1	*6137.3*	80.1
$3p_1$			2	*6057.2*	
$3F$	$6s\ 4f$	$^1F^\circ$	3	*6136.7*	
d_3''	$5d\ 7s$	^3D	1	6095.5	266.5
d_2''			2	5829.0	482.6
d_1''			3	5400.4	
q_9	—	13°	1 or 2	*5794.3*	
q_8	$5d\ 7p$	$^3D^\circ$	1	*5533.8*	581.8
q_6			2	*4952.0*	462.6
			3	*4489.4*	
q_7	—	14°	1 or 2 or 3	*5518.3*	
$3P$	$6s\ 8p$	$^1P^\circ$	1	*5039.5*	
$4D$	$6s\ 8d$	^1D	2	4987.8	
$2f_3''$	$5d\ 7p$	$^3F^\circ$	2	*4966.3*	218.8
$2f_2''$			3	*4747.5*	188.9
$2f_1''$			4	*4558.6*	
$3s$	$6s\ 9s$	^3S	1	4934.0	
$4f_3$	$6s\ 5f$	$^3F^\circ$	2	*4634.6*	24.2
$4f_2$			3	*4610.4*	5.1
$4f_1$			4	*4605.3*	

(*Continued*)

	Configuration	Symbol	J	Term value	$\Delta\nu$
$4F$	$6s\ 5f$	$^1F^\circ$	3	*4254.4*	
$4d_3$	$6s\ 8d$	^3D	1	4067.5	12.1
$4d_2$			2	4055.4	14.4
$4d_1$			3	4041.0	
$4P$	$6s\ 9p$	$^1P^\circ$	1	*3529.9*	
$5D$	$6s\ 9d$	^1D	2	3472.6	
$4s$	$6s\ 10s$	^3S	1	3366.5	
$5f_3$	$6s\ 6f$	$^3F^\circ$	2	*3213.8*	3.7
$5f_2$			3	*3210.1*	5.9
$5f_1$			4	*3204.2*	
$5d_3$	$6s\ 9d$	^3D	1	2888.7	17.3
$5d_2$			2	2871.4	27.6
$5d_1$			3	2843.8	
$5P$	$6s\ 10p$	$^1P^\circ$	1	*2721.0*	
$6D$	$6s\ 10d$	^1D	2	2531.7	
$5s$	$6s\ 11s$	^3S	1	2404.5	
$6f_3$	$6s\ 7f$	$^3F^\circ$	2	*2351.2*	2.5
$6f_2$			3	*2348.7*	2.4
$6f_1$			4	*2346.3*	
q_5	—	15°	1 or 2	*2264.4*	
$6d_3$	$6s\ 10d$	^3D	1	2137.1	2.3
$6d_2$			2	2134.8	0.6
$6d_1$			3	2124.2	
$6P$	$6s\ 11p$	$^1P^\circ$	1	*2044.0?*	
$7f_3$	$6s\ 8f$	$^3F^\circ$	2	*1790.5*	2.5
$7f_2$			3	*1788.0*	2.8
$7f_1$			4	*1785.2*	
$7d^3$	$6s\ 11d$	^3D	1	—	
$7d_2$			2	1649.1	2.3
$7d_1$			3	1646.8	

BARIUM I

(*Concluded*)

	Configuration	Symbol	J	Term value	$\Delta\nu$
$7P$	$6s\ 12p$	$^1P^\circ$	1	*1606.0 ?*	
$8f_3$	$6s\ 9f$	$^3F^\circ$	2	*1415.4*	7.6
$8f_2$			3	*1407.8*	6.2
$8f_1$			4	*1401.6*	
$9f_3$	$6s\ 10f$	$^3F^\circ$	2	*1134.2*	1.4
$9f_2$			3	*1132.8*	0.6
$9f_1$			4	*1132.2*	
$10f_3$	$6s\ 11f$	$^3F^\circ$	2	*933.0*	0.1
$10f_2$			3	*932.9*	0.7
$10f_1$			4	*932.2*	
$11f_3$	$6s\ 12f$	$^3F^\circ$	2	*782.6*	0.9
$11f_2$			3	*781.7*	
$12f_3$	$6s\ 13f$	$^3F^\circ$	2	*665.2*	0.5
$12f_2$			3	*664.7*	
$13f_2$	$6s\ 14f$	$^3F^\circ$	3	*572.4*	
$14f_2$	$6s\ 15f$	$^3F^\circ$	3	*499.0*	
q_{12}	—	16	2 or 3	−6615.6	

SERIES

6s *ms*			
m	$^3S_1$	m	$^1S_0$
		6	42029.4
7	15869.3	7	16399.4
8	8124.3		
9	4934.0		
10	3366.5		
11	2404.5		

SERIES (*Concluded*)

6s mp					
m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	m	$^1P_1^\circ$
6	*29763.3*	*29392.8*	*82514.8*	6	*23969.2*
7	*11286.4*	*11214.2*	*11042.3*	7	*9482.2*
8	*6186.9*	*6137.3*	*6057.2*	8	*5039.5*
				9	*3529.9*
				10	*2721.0*
				11	*2044.0 ?*
				12	*1606.0 ?*

6s md					
m	$^3D_1$	$^3D_2$	$^3D_3$	m	$^1D_2$
5	32995.6	32814.1	32433.0	5	30634.1
6	11333.9	11279.0	11211.6	6	13800.4
7	6320.1	6267.3	6244.2	7	7931.0
8	4067.5	4055.4	4041.0	8	4987.8
9	2888.7	2871.4	2843.8	9	3472.6
10	2137.1	2134.8	2124.2	10	2531.7
11		1649.1	1646.8		

6s mf					
m	$^3F_2^\circ$	$^3F_3^\circ$	$^3F_4^\circ$	m	$^1F_3^\circ$
4	*7426.8*	*7412.8*	*7398.6*	4	*13475.2*
5	*4634.6*	*4610.4*	*4605.3*	5	*6136.7*
6	*3213.8*	*3210.1*	*3204.2*	6	*4254.4*
7	*2351.2*	*2348.7*	*2346.3*		
8	*1790.5*	*1788.0*	*1785.2*		
9	*1415.4*	*1407.8*	*1401.6*		
10	*1134.2*	*1132.8*	*1132.2*		
11	*933.0*	*932.9*	*932.2*		
12	*782.6*	*781.7*			
13	*665.2*	*664.7*			
14		*572.4*			
15		*499.0*			

Ba II $\qquad Z = 56$

55 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\, 5p^6\, 6s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 9.96 volts

The classification of Ba II has been made according to Paschen-Götze and is slightly different from the one given in Fowler. The absolute term values are given with respect to the $5p^6\ {}^1S_0$ of Ba III.

Reference

H. N. Russell and F. A. Saunders, *Astrophys. Journ.* **61**, 38 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5p^6\, 6s$	^2S	$\frac{1}{2}$	80655.5	
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	75781.4 74980.3	801.1
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*60393.5* *58702.5*	1691.0
$7s$	^2S	$\frac{1}{2}$	38300.0	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	34705.0 34500.3	204.7
$4f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*32395.9* *32171.2*	224.7
$8s$	^2S	$\frac{1}{2}$	22628.6	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	20853.0 20760.3	92.7
$5f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*21711.9* *21479.9*	232.0

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5p^6\,6f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*16181.9* *15957.9*	224.0
$9s$	^2S	$\frac{1}{2}$	14973.7	
$8d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	13981.8 13927.7	54.1
$10s$	^2S	$\frac{1}{2}$	10703.8	
$9d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	10101.2 10054.4	46.8

Be I $Z = 4$

4 electrons $1s^2\,2s^2\ {}^1S_0$

First ionization potential = 9.281 volts

These terms are from the work of Paschen and Kruger. The singlets and triplets, although well established with respect to each other by the long series, are given in separate tables since no intercombinations have been observed. Absolute values of both singlets and triplets are with respect to $2s\ {}^2S_{\frac{1}{2}}$ of Be II. Several of the higher terms are uncertain.

Reference

F. Paschen and P. G. Kruger, *Ann. d. Physik* **8,** 1005 (1931).

Configuration	Symbol	J	Term value
$2s^2$	^1S	0	75194.3
$2s\,2p$	$^1P°$	1	*32629*
$2s\,3s$	^1S	0	20517.1
$2s\,3p$	$^1P°$	1	*15007 ?*
$2s\,3d$	^1D	2	10766.1
$2s\,4s$	^1S	0	9948.9
$2s\,4p$	$^1P°$	1	*7966 ?*
$2s\,4d$	^1D	2	6413.1
$2s\,5s$	^1S	0	5872.0
$2s\,5d$	^1D	2	4192.0
$2s\,6s$	^1S	0	3873.6
$2p^2$	^1D	2	3695.4 ?

(*Concluded*)

Configuration	Symbol	J	Term value
$2s\ 6d$	^1D	2	2943.2
$2s\ 7s$	^1S	0	2746.1
$2s\ 7d$	^1D	2	2177.1
$2s\ 7s$	^1S	0	2047.3
$2s\ 7d$	^1D	2	1674.5
$2s\ 8d$	^1D	2	1327.2
$2s\ 9d$	^1D	2	1076.9
$2p^2$	^1S	0	−3882.0 ?

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p$	$^3P^\circ$	0	*53212.86*	
		1	*53212.18*	0.68
		2	*53209.83*	2.35
$2s\ 3s$	^3S	1	23110.22	
$2s\ 3p$	$^3P^\circ$	0, 1, 2	*18351 ?*	
$2p^2$	^3P	0	15497.68	
		1	15496.28	1.40
		2	15494.25	2.03
$2s\ 3d$	^3D	1, 2, 3	13137.5	
$2s\ 4s$	^3S	1	10684.6	
$2s\ 4p$	$^3P^\circ$	0, 1, 2	*9243 ?*	
$2s\ 4d$	^3D	1, 2, 3	7248.7	
$2s\ 5s$	^3S	1	6183.0	
$2s\ 5p$	$^3P^\circ$	0, 1, 2	*5557.8?*	
$2s\ 5d$	^3D	1, 2, 3	4585.6	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
2s 6s	^3S	1	4030.4	
2s 6p	$^3P^\circ$	0, 1, 2	*3709.4 ?*	
2s 6d	^3D	1, 2, 3	3161.7	
2s 7s	^3S	1	2836.9	
2s 7d	^3D	1, 2, 3	2310.4	
2s 8s	^3S	1	2103.2	
2s 8d	^3D	1, 2, 3	1762.7	
2s 9d	^3D	1, 2, 3	1389.1	
2s 10d	^3D	1, 2, 3	1121.7	
2s 11d	^3D	1, 2, 3	923.7	
2s 12d	^3D	1, 2, 3	776.0	
2p 3s	$^3P^\circ$	0	*−10362.67*	
		1	*−10364.72*	2.05
		2	*−10368.64*	3.92
2p 3p	^3P	0	−14756.3 ?	
		1	−14757.3 ?	1.0
		2	−14759.2 ?	1.9
2p 3d	$^3D^\circ$	1	*−18997.22 ?*	
		2	*−18997.82*	0.60
		3	*−18998.97*	1.15

Be II $\qquad Z = 4$

3 electrons $\qquad 1s^2\,2s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 18.12 volts

These term values of the beryllium spark spectrum are from the work of Paschen and Kruger.

Reference

F. Paschen and P. G. Kruger, *Ann. d. Physik* **8**, 1005 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$1s^2\,2s$	^2S	$\frac{1}{2}$	146881.7	
$2p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*114952.9* *114946.3*	6.6
$3s$	^2S	$\frac{1}{2}$	58650.5	
$3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*50385.3* *50383.5*	1.8
$3d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	48828.5	
$4s$	^2S	$\frac{1}{2}$	31416.5	
$4p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*28122*	
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	27459.5	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*27437.1*	
$5s$	^2S	$\frac{1}{2}$	19545.6	
$5p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*17911.5*	
$5d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	17570.4	
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*17559.8*	
$6s$	^2S	$\frac{1}{2}$	13322.6	

(*Concluded*)

Configuration	Symbol	J	Term value	
$1s^2\,6p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*12396.1*	
$6d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	12199.7	
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*12193.6*	
$7s$	^2S	$\frac{1}{2}$	9655.7	
$7p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*9086*	
$7d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	8961.7	
$7f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*8958.6*	
$8d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	6861.3	

Be III $\qquad Z = 4$

2 electrons $\qquad 1s^2\ {}^1S_0$

Ionization potential = 153.1 volts

These terms are taken from the work of Edlén and Ericson.

References

B. Edlén, H. Ericson, *Zeits. f. Physik* **59**, 656 (1930).
B. Edlén, *Nature*, **127**, 405 (1931).

Configuration	Symbol	J	Term value
$1s^2$	${}^1S$	0	1240800 ± 800
$1s\ 2p$	${}^1P^\circ$	1	*243300*
$3p$	${}^1P^\circ$	1	*108300*
$4p$	${}^1P^\circ$	1	*70900*
$5p$	${}^1P^\circ$	1	*38700*
$6p$	${}^1P^\circ$	1	*26800*

Be IV $Z = 4$

1 electron $1s\ ^2S_{\frac{1}{2}}$

Ionization potential = 216.6 volts

For a more detailed discussion compare H I. The terms of this spectrum are given by

$$\frac{E(n, l, j)}{hc} = \frac{R_{Be} \times 16}{n^2} + \frac{5.822 \times 256}{n^3}\left(\frac{3}{4n} - \frac{1}{j + \frac{1}{2}}\right)$$

where

$$R_{Be} = \frac{R}{\left(1 + \frac{m}{M_{Be}}\right)} = 109730.8$$

The two first lines of the Lyman series of this spectrum have been observed by Edlén and Ericson, who used the calculated wave lengths as standards in this region of the extreme ultra-violet. The two lines are

$\lambda = 75.925$ Å $\nu = 1317084$ cm.$^{-1}$
64.063 1560962

The fine structure could not be observed.

References

B. Edlén and A. Ericson, *Nature* **125**, 233 (1930).
B. Edlén, *Nature* **127**, 405 (1931).

83 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p^3\ {}^4S_{1\frac{1}{2}}$

The classification of the arc spectrum of bismuth has been given by Ruark, Mohler, Foote, and Chenault, and by Thorsen, and has been supplemented by more recent work of Toshnival. Due to the almost complete (j, j) coupling, multiplet assignments cannot be made except for the lowest terms.

Bismuth has a hyperfine structure which has been attributed to the presence of a nuclear spin $I = 4\frac{1}{2}$. The hyperfine separations, as observed by Back, are given in the second table.

References

V. Thorsen, *Zeits. f. Physik* **40**, 642 (1926). Levels and classified lines.

A. E. Ruark, F. L. Mohler, P. D. Foote, and R. L. Chenault, *Bur. Stand. Sci. Papers* **19**, 463 (1924). Levels and classified and unclassified lines.

G. R. Toshniwal, *Phil. Mag.* **4**, 774 (1927). Levels and classified and unclassified lines.

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E. Back and S. A. Goudsmit, *Zeits. f. Physik* **47**, 174 (1928). Zeeman effect and hyperfine structure.

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Configuration	Symbol	J	Term value	$\Delta\nu$	g value
$6p^3$	${}^4S^\circ$	$1\frac{1}{2}$	*0*		1.654
$6p^3$	${}^2D^\circ$	$1\frac{1}{2}$	*11418*	1019	1.225
		$2\frac{1}{2}$	*15437*		1.20
$6p^3$	${}^2P^\circ$	$\frac{1}{2}$	*21660*	11505	0.667
		$1\frac{1}{2}$	*33165*		
$6p^2\ 7s$	1	$\frac{1}{2}$	32588		2.088

(*Concluded*)

Configuration	Symbol	J	Term value	g value
—	20°	$1\frac{1}{2}$	*41127*	
$6p^2\,5d$	2	$1\frac{1}{2}$	43912	0.79
$5d$	3	$2\frac{1}{2}$	44817	1.20
$7s$	4	$1\frac{1}{2}$	44865	1.676
$7s$	5	$\frac{1}{2}$	45915	1.30
	6	$\frac{1}{2}$	47372	
$7s$	7	$2\frac{1}{2}$	48489	1.41
$7s$	8	$1\frac{1}{2}$	49461	0.98
	9	$1\frac{1}{2}$	51019	
	10	$2\frac{1}{2}$	51158	
	19	$\frac{1}{2}$	52252 ?	
	11	$2\frac{1}{2}$	53877	
	12	$1\frac{1}{2}$	53976	
	13	$1\frac{1}{2}$	56570	
	14	$2\frac{1}{2}$	57076	
	15	$1\frac{1}{2}$	58272	
	16	$2\frac{1}{2}$	43209 ?	
	17	$1\frac{1}{2}$	64020 ?	
	18	$1\frac{1}{2}$	66103 ?	

Hyperfine structure separations

	$F = 2$	3	4	5	6	7
$6p^3\ ^4S_{1\frac{1}{2}}^{\circ}$			Total ~ -0.10			
$^2D_{1\frac{1}{2}}^{\circ}$		-0.152	-0.198	-0.255		
$^2D_{2\frac{1}{2}}^{\circ}$	0.254	0.310	0.400	0.495	0.571	
$^2P_{\frac{1}{2}}^{\circ}$			1.875			
$6p^2\,7s\ 1_{\frac{1}{2}}$			0.830			
$6p^2\,5d\ 2_{1\frac{1}{2}}$			Total ~ 0.10			
$6p^2\,5d\ 3_{2\frac{1}{2}}$			Total less than 0.10			
$6p^2\,7s\ 4_{1\frac{1}{2}}$			Total ~ -0.10			
$6p^2\,7s\ 5_{\frac{1}{2}}$			-0.708			
$6_{\frac{1}{2}}$			0.20			
$6p^2\,7s\ 7_{2\frac{1}{2}}$	0.380	0.506	0.633	0.760	0.887	
$6p^2\,7s\ 8_{1\frac{1}{2}}$		0.379	0.473	0.563		

82 electrons

$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,4f^{14}\,5s^2\,5p^6\,5d^{10}\,6s^2\,6p^2\ {}^3P_0$

This classification is given by McLennan, McLay, and Crawford, who also measured the hyperfine structure for a few lines. In the last column the total hyperfine structure separations are given according to measurements made by Fisher and Goudsmit.

References

J. C. McLennan, A. B. McLay, and M. F. Crawford, *Proc. Roy. Soc.* **A129**, 579 (1930).

R. A. Fisher and S. Goudsmit, *Phys. Rev.* **37**, 1057 (1931).

Configuration	Symbol	J	Term value	Remarks	Hyperfine structure
$6s^2\,6p^2$	1	0	0	^3P $p_{\frac12}$ $p_{\frac12}$	
	2	1	13322	^3P $p_{\frac12}$ $p_{1\frac12}$	
	3	2	17025	^3P $p_{\frac12}$ $p_{1\frac12}$	
	4	2	33930	^1D $p_{1\frac12}$ $p_{1\frac12}$	
	5	0	44166	^1S $p_{1\frac12}$ $p_{1\frac12}$	
$6p\ (^2P_{\frac12})\ 7s$	1°	0	*69126*	$^3P^{\circ}$	
	2°	1	*69590*	$^3P^{\circ}$	3.91
$6s\ 6p^3$	4°	2	*76143*		8.2
$6p\ (^2P_{\frac12})\ 6d_{1\frac12}$	5°	2	*79083*		2.55
	6°	1	*80569*		−1.65
$6d_{2\frac12}$	7°	2	*82041*		2.0
	8°	3	*82349*		
$6p\ (^2P_{\frac12})\ 7p_{\frac12}$	6	1	84273		
	7	0	87070		
$7p_{1\frac12}$	8	1	88559		1.02
$6p\ (^2P_{1\frac12})\ 7s$	9°	2	*88763*	$^3P^{\circ}$	2.2
$6p\ (^2P_{\frac12})\ 7p_{1\frac12}$	9	2	88781		2.50

BISMUTH II

(*Concluded*)

Configuration	Symbol	J	Term value	Remarks	Hyperfine structure
$6p\ (^2P_{1\frac{1}{2}})\ 7s$	10°	1	*89877*	$^1P^{\circ}$	−0.53
$6p\ (^2P_{\frac{1}{2}})\ 5f$	10	2	105077		−0.2
$6p\ (^2P_{1\frac{1}{2}})\ 7p$	11	2	105263		
$6p\ (^2P_{\frac{1}{2}})\ 5f$	12	3	105281		−0.7
	13	3	105443		2.0
	14	4	105720		
$6p\ (^2P_{1\frac{1}{2}})\ 7p$	15	1	106441		−0.4
	16	3	108272		0.4
$6p\ (^2P_{\frac{1}{2}})\ 8p$	17	1	108398		−0.1
$6p\ (^2P_{1\frac{1}{2}})\ 7p$	18	1	109097		
	19	2	109897		0.78
	20	0	110924		

81 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p\ ^2P_{\frac{1}{2}}^\circ$

Ionization potential = 25 volts

This classification is taken from a paper by McLennan, McLay, and Crawford. The lowest state has not been found, its absolute value is about 200000 cm.$^{-1}$ The total hyperfine structure separations entered in the last column are from measurements made by these authors and by Fisher and Goudsmit.

References

J. C. McLennan, A. B. McLay, and M. F. Crawford, *Proc. Roy. Soc.* **A129,** 579 (1930).

G. Arvidsson, *Nature* **126,** 565 (1930).

R. A. Fisher and S. Goudsmit, *Phys. Rev.* **37,** 1057 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$	Hyperfine structure
$6s^2\ 6p$	$^2P^\circ$	$\frac{1}{2}$	—		
		$1\frac{1}{2}$	*184390*		
$6s\ 6p^2$	1	$1\frac{1}{2}$	123143		7.5
	2	$2\frac{1}{2}$	116943		12.5
$6s^2\ 7s$	^2S	$\frac{1}{2}$	111105		2.36
$6s^2\ 6d$	^2D	$1\frac{1}{2}$	110027	6292	
		$2\frac{1}{2}$	103735		
$6s\ 6p^2$	3	$2\frac{1}{2}$	89765		9.3
$6s^2\ 7p$	$^2P^\circ$	$\frac{1}{2}$	*89188*	5135	0.52
		$1\frac{1}{2}$	*84053*		0.3
$6s^2\ 5f$	$^2F^\circ$	$3\frac{1}{2}$	*68725*	−100	
		$2\frac{1}{2}$	*68825*		

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s^2\ 8s$	^2S	$\frac{1}{2}$	61054	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	57095 55084	2011
$6f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*43994* *43938*	−56
$5g$	^2G	$4\frac{1}{2}$ $3\frac{1}{2}$	39946 39943	−3
$6g$	^2G	$4\frac{1}{2}$ $3\frac{1}{2}$	27713 27710	−3
$7h$	$^2H^\circ$	$5\frac{1}{2}, 4\frac{1}{2}$	*20156*	

Bi IV $Z = 83$

80 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ {}^1S_0$

The hyperfine structure of two lines in the extreme ultra-violet, observed by Arvidsson, makes it probable that these lines belong to Bi IV. Both lines show the same triplet structure but in opposite direction; the first line has the smaller triplet distance on the long wave-length side.

λ 1317.1 Å	75924 cm.$^{-1}$	$\Delta\nu$ = 5.7 and	7.3 cm.$^{-1}$
1103.4	90629	7.0	5.3

The classification of the first line is probably $6s^2\ {}^1S_0 - 6s\,6p\ {}^3P_1^\circ$. The second line may be a transition with $6s\,6p\ {}^3P_1$ (to which the hyperfine structure is ascribed) as final level.

Reference

G. Arvidsson, *Nature* **126,** 565 (1931).

79 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s\ {}^2S_{\frac{1}{2}}$

Arvidsson has found two lines of which the hyperfine structure shows that they are probably the principal doublet of Bi V.

Reference

G. Arvidsson, *Nature* **126**, 565 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$	Remarks
$6s$	^2S	$\frac{1}{2}$	0		13 cm.$^{-1}$, hyperfine structure
$6p$	$^2P^\circ$	$\frac{1}{2}$	*87765*	27908	
		$1\frac{1}{2}$	*115673*		

Br I $Z = 35$

35 electrons $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5\ {}^2P_{1\frac{1}{2}}^{\circ}$

First ionization potential = 11.80 volts

This classification has been taken from a paper by Kiess and De Bruin. Large deviations from multiplet structure are present. The lowest state has been estimated to be 95550 cm.$^{-1}$ with respect to $4p^4\ {}^3P$ of Br II.

Reference

C. C. Kiess and T. L. de Bruin, *Bur. Stand. Journ. Res.* **4,** 667 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\ 4p^5$	$^2P^{\circ}$	$1\frac{1}{2}$ $\frac{1}{2}$	*0* *3685*	−3685
$4p^4\ (^3P)\ 5s$	^4P	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	63429.82 64900.50 66877.16	−1470.68 −1976.66
$4p^4\ (^3P)\ 5s$	^2P	$1\frac{1}{2}$ $\frac{1}{2}$	67176.87 68963.52	−1786.65
$4p^4\ (^3P)\ 5p$	$^4P^{\circ}$	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*74665.67* *75002.52* *75807.33*	−336.85 −804.81
$4p^4\ (^3P)\ 5p$	$^4D^{\circ}$	$3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*75514.82* *75690.44* *76736.45* *78069.29*	−175.62 −1046.01 −1332.84
$4p^4\ (^1S)\ 5s$	^2S	$\frac{1}{2}$	75901.89	
$4p^4\ (^1D)\ 5s$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	77305.93 77324.11	18.18
$4p^4\ (^3P)\ 5p$	$^2D^{\circ}$	$2\frac{1}{2}$	*78504.88* *79689.16*	−1184.28

(*Continued*)

Configuration	Symbol	J	Term value	Δν
$4p^4\ (^3P)\ 5p$	$^4S°$	1½	*78669.92*	
$4p^4\ (^3P)\ 5p$	$^2P°$	½ 1½	*78858.98* *79171.64*	312.66
$4p^4\ (^3P)\ 5p$	$^2S°$	½	*79861.30*	
$4p^4\ (^3P)\ 6p$	$^4P°$	2½ 1½ ½	*85520.14* *85579.60* *85792.56*	−59.46 −212.96
$4p^4\ (^3P)\ 6p$	$^4D°$	3½ 2½ 1½ ½	*85756.22* *85813.82* *85937.22* *86429.88*	−57.60 −123.40 −492.66
$4p^4\ (^3P)\ 6p$	$^2P°$	1½ ½	*87252.57* *87492.36*	−239.79
$4p^4\ (^3P)\ 7s$	^2P	1½ ½	87748.30 90102.93	−2354.63
$4p^4\ (^3P)\ 7s$	^4P	2½ 1½ ½	88128.33 88268.77 90285.62	−140.44 −2016.85
$4p^4\ (^1D)\ 5p$	$^2P°$	1½ ½	*88476.73* *88552.92*	−76.19
$4p^4\ (^1D)\ 5p$	$^2F°$	3½ 2½	*88658.93* *88674.92*	−15.99
$4p^4\ (^3P)\ 6p$	$^4S°$	1½	*88947.12*	
$4p^4\ (^3P)\ 6p$	$^2D°$	1½ 2½	*88841.29* *89025.05*	183.76
$4p^4\ (^3P)\ 6p$	$^2S°$	½	*89140.50*	
$4p^4\ (^3P)\ 7p$	$^4P°$	2½ 1½ ½	*89541.96* *89779.48* *89941.14*	−237.52 −161.66
$4p^4\ (^1S)\ 5p$	$^2P°$	½ 1½	*89758.04* *89899.16*	141.12

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^4\,(^1D)\,5p$	$^2D^\circ$	$2\frac{1}{2}$	*89786.97*	
				−67.37
		$1\frac{1}{2}$	*89854.34*	
$4p^4\,(^3P)\,4d$	^4D	$\frac{1}{2}$	89722.68	
		$3\frac{1}{2}$	89854.02	
		$1\frac{1}{2}$	89861.13	
		$2\frac{1}{2}$	89941.29	
$4p^4\,(^3P)\,4d$	^4P	$\frac{1}{2}$	90186.50	
				372.62
		$1\frac{1}{2}$	90559.12	
				223.08
		$2\frac{1}{2}$	90782.20	
$4p^4\,(^3P)\,4d$	^4F	$4\frac{1}{2}$	90238.19	
				−22.97
		$3\frac{1}{2}$	90261.16	
				−87.17
		$2\frac{1}{2}$	90348.33	
				−73.17
		$1\frac{1}{2}$	90421.50	
$4p^4\,(^3P)\,4d$	^2F	$2\frac{1}{2}$	91432.00	
				30.44
		$3\frac{1}{2}$	91462.44	
$4p^4\,(^3P)\,4d$	^2D	$2\frac{1}{2}$	91646.58	
				−165.06
		$1\frac{1}{2}$	91811.64	
$4p^4\,(^3P)\,4d$	^2P	$1\frac{1}{2}$	—	
		$\frac{1}{2}$	91785.35	
$4p^4\,(^3P)\,5d$	^4D	$\frac{1}{2}$	91733.24	
		$3\frac{1}{2}$	91748.84	
		$1\frac{1}{2}$	91793.40	
		$2\frac{1}{2}$	91803.62	
$4p^4\,(^3P)\,5d$	^4F	$4\frac{1}{2}$	91844.52	
				−29.89
		$3\frac{1}{2}$	91874.41	
				−75.42
		$2\frac{1}{2}$	91949.83	
		$1\frac{1}{2}$	—	
$4p^4\,(^3P)\,5d$	^4P	$2\frac{1}{2}$	92722.87	
		$\frac{1}{2}$	92736.30	
		$1\frac{1}{2}$	92746.84	

Br II $Z = 35$

34 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^3\,5s\;{}^5S_2$

These terms are from the work of Deb.

Reference

S. C. Deb, *Proc. Roy. Soc.* **A127**, 197 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^3\,(^4S)\,5s$	$^5S^\circ$	2	*0*	
$4p^3\,(^4S)\,4d$	$^5D^\circ$	0	*157*	
				29
		1	*186*	
				29
		2	*215*	
				37
		3	*252*	
				40
		4	*292*	
$4p^3\,(^4S)\,5p$	^5P	1	20970	
				64
		2	21034	
				148
		3	21182	
$4p^3\,(^4S)\,5d$	$^5D^\circ$	0	*42271*	
				11
		1	*42282*	
				17
		2	*42299*	
				21
		3	*42320*	
				41
		4	*42361*	
$4p^3\,(^4S)\,6s$	$^5S^\circ$	2	*42113*	

Br III $\quad Z = 35$

33 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^3\; {}^4S^\circ_{1\frac{1}{2}}$

The term values are derived from a paper by Deb. The discrepancies in frequency differences allowed in the classsification are so large that several terms seem uncertain. It is extraordinary that the $4p^2\,4d$ multiplets are all found to be inverted.

Deb gives the absolute value of the lowest state as 210,000 cm.$^{-1}$

Reference

S. C. Deb, *Proc. Roy. Soc.* **127,** 197 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^2\,5s$	^4P	$\frac{1}{2}$	0	
		$1\frac{1}{2}$	516	516
		$2\frac{1}{2}$	1354	838
$4p^2\,4d$	^4P	$2\frac{1}{2}$	4514	
		$1\frac{1}{2}$	4978	−464
		$\frac{1}{2}$	5184	−206
$4p^2\,4d$	^4D	$3\frac{1}{2}$	7343	
		$2\frac{1}{2}$	7634	−291
		$1\frac{1}{2}$	7752	−118
		$\frac{1}{2}$	7812	−60
$4p^2\,4d$	^4F	$4\frac{1}{2}$	11023	
		$3\frac{1}{2}$	11102	−79
		$2\frac{1}{2}$	11147	−35
		$1\frac{1}{2}$	11177	−30
$4p^2\,5p$	$^4D^\circ$	$\frac{1}{2}$	*27764*	
		$1\frac{1}{2}$	*28093*	329
		$2\frac{1}{2}$	*28670*	577
		$3\frac{1}{2}$	*29417*	747
$4p^2\,5p$	$^4P^\circ$	$\frac{1}{2}$	*31609*	
		$1\frac{1}{2}$	*32080*	471
		$2\frac{1}{2}$	*32852*	772
$4p^2\,5p$	$^4S^\circ$	$1\frac{1}{2}$	*34452*	

BROMINE III

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^2\,5d$	^4F	$1\frac{1}{2}$	65203	
				268
		$2\frac{1}{2}$	65471	
				479
		$3\frac{1}{2}$	65950	
				808
		$4\frac{1}{2}$	66758	
$4p^2\,5d$	^4D	$\frac{1}{2}$	68037	
				110
		$1\frac{1}{2}$	68147	
				357
		$2\frac{1}{2}$	68504	
				585
		$3\frac{1}{2}$	69089	
$4p^2\,5d$	^4P	$\frac{1}{2}$	70142	
				468
		$1\frac{1}{2}$	70610	
				604
		$2\frac{1}{2}$	71214	

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^2\,5s$	^2P	$\frac{1}{2}$	0	
				1138
		$1\frac{1}{2}$	1138	
$4p^2\,5s$	^2D	$1\frac{1}{2}$	1782	
				1285
		$2\frac{1}{2}$	3067	
$4p^2\,4d$	^2P	$1\frac{1}{2}$	3530	
				−957
		$\frac{1}{2}$	4487	
$4p^2\,4d$	^2D	$2\frac{1}{2}$	7355	
				−785
		$1\frac{1}{2}$	8140	
$4p^2\,4d$	^2F	$3\frac{1}{2}$	12598	
				−113
		$2\frac{1}{2}$	12711	
$4p^2\,5p$	$^2D^\circ$	$1\frac{1}{2}$	*28770*	
				1367
		$2\frac{1}{2}$	*30137*	
$4p^2\,5p$	$^2P^\circ$	$\frac{1}{2}$	*32354*	
				1171
		$1\frac{1}{2}$	*33525*	
$4p^2\,5d$	^2F	$2\frac{1}{2}$	66444	
				722
		$3\frac{1}{2}$	67166	
$4p^2\,5d$	^2D	$1\frac{1}{2}$	68683	
				1188
		$2\frac{1}{2}$	69871	
$4p^2\,5d$	^2P	$\frac{1}{2}$	70757	
				980
		$1\frac{1}{2}$	71737	

Br IV $\quad Z = 35$

32 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^2\ {}^3P$

This classification has been given by Deb. The lowest state has not been found. It is very unusual that the $4p\, 5s\, {}^3P$ is inverted. Many of the terms seem to be quite uncertain.

Reference

S. C. Deb, *Proc. Roy. Soc.* **A127,** 197 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p\, 5s$	${}^1P^\circ$	1	*0*	
$4p\, 5s$	${}^3P^\circ$	2	*933*	
				−1093
		1	*2026*	
				−506
		0	*2532*	
$4p\, 5p$	${}^3D$	1	34899	
				1193
		2	36092	
				1517
		3	37609	
$4p\, 5p$	${}^1D$	2	37990	
$4p\, 5p$	${}^3P$	0	40091	
				364
		1	40455	
				607
		2	41062	
$4p\, 5p$	${}^1P$	1	42176	
$4p\, 5p$	${}^3S$	1	43179	

Br V $\quad Z = 35$

31 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p\ ^2P^{\circ}_{\frac{1}{2}}$

In this spectrum Deb has classified a few lines.

Reference

S. C. Deb, *Proc. Roy. Soc.* **A127**, 197 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\,5s$	^2S	$\frac{1}{2}$	0	
$4s^2\,4d$	^2D	$1\frac{1}{2}$	7506.3	642.9
		$2\frac{1}{2}$	8149.2	
$4s^2\,5p$	$^2P^{\circ}$	$\frac{1}{2}$	*41018.2*	2571.9
		$1\frac{1}{2}$	*43590.1*	

C I $\qquad$ $Z = 6$

6 electrons $\qquad$ $1s^2\,2s^2\,2p^2\ {}^3P_0$

First ionization potential = 11.217 volts

Paschen and Kruger have recently extended the series of the arc spectrum of carbon and have observed intercombinations which place the singlets with respect to the triplets. They give the absolute values of the terms with respect to the $2p\ {}^2P_{1\frac{1}{2}}$ of C II.

The low terms have been given in the first table and all the terms given in the second arranged in the series scheme.

References

S. B. Ingram, *Phys. Rev.* **34**, 421, (1929).
F. Paschen and G. Kruger, *Ann. d. Physik* **7**, 1 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^2$	${}^3P$	0	90878.3	
				14.8
		1	90863.5	
				27.5
		2	90836	
$2s^2\,2p^2$	${}^1D$	2	80686	
$2s^2\,2p^2$	${}^1S$	0	69231	
$2s^2\,2p\,3s$	${}^3P^\circ$	0	*30547.0*	
				20.0
		1	*30527.0*	
				40.1
		2	*30486.9*	
$2s^2\,2p\,3s$	${}^1P^\circ$	1	*28898*	
$2s\,2p^3$	${}^3D^\circ$	2	*26792*	
$2s^2\,2p\,3p$	${}^1D$	2	22780	
$2s^2\,2p\,3p$	${}^3D$	1	21190.2	
				21.2
		2	21169.0	
				33.7
		3	21135.3	
$2s^2\,2p\,3p$	${}^3S$	1	20139	
$2s\,2p^3$	${}^3P^\circ$	1, 2	*15626*	

SERIES

$2s^2\,2p^2$								
^3P	0	90878.3	^1D	2	80686	^1S	0	69231
	1	90863.5						
	2	90836						

$2s^2\,2p\,ms$				
	$^3P^\circ$			$^1P^\circ$
m	$J=0$	1	2	0
3	*30547.0*	*30527.0*	*30486.9*	*28898*
4	*12777.9*	*12762.8*	*12732.4*	*12149.2*
5	*7146.0*	*7130.8*	*7091.8*	*6846.2*
6		*4579.7*	*4536.0*	*4388.2*
7		*3197.1*	*3148.2*	*3049.0*
8		*2362.2*	*2311.2*	*2241*
9		*1828.5*	*1771.0*	
10			*1402.8*	

$2s^2\,2p\,mp$					
	^3D			^1D	^3S
m	$J=1$	2	3	2	1
3	21190.2	21169.0	21135.3	22780	20139
4	10694.5	16087.5	10657.7	10317	9774.7
	^3P			^1P	^1S
m	$J=0$	1	2	1	0
3	19527.1	19514.6	19494.2	19018	—
4	9568.5	9554	9536	8628 ?	9110

SERIES (*Concluded*)

$2s^2\,2p\,md$

m	$^3D^\circ$ $J=1$	$^3D^\circ$ 2	$^3D^\circ$ 3	$^3P^\circ$ 2	$^3P^\circ$ 1	$^3P^\circ$ 0
3	12579.2	12574.2	12565.0	11570.0	11560.5	11556.2
4	7050.6	7044.2	7033.7	6778.4	6768.3	
5	4509	4509	4488.2	4377.1	4361.9	
6		3128.3	3108.6	3050.6	3040	
7			2274.7	2242.2	2232.8	
8			1735.3	1723.7		
9			1367.0			
10			1102.8			
11			912.1			

m	$^3F^\circ$ 2	$^3F^\circ$ 3	$^3F^\circ$ 4	$^1D^\circ$ 2	X° ($^1F_3^\circ$?) 3 ?	$^1F^\circ$ 3	$^1P^\circ$ 1
3	12680.0 ?	12664.8	12629.8 ?	12348	—	13198.6	12541
4	7120.2	7109.7		6930	—	7379.7	6996.6
5	4481.7			4430	4551.8	4692	4466
6				3073	3165.6	3249.5	3084.4
7				2256	2334		
8				1725	1799		
9				1363	—		
10				—	1145		
11				911	934		

$2s\,2p^3$

$^3D^\circ$	2	26792	$^3P^\circ$	2, 1	15626	$^1D^\circ$	2	12665	$^1P^\circ$	1	12587

C II $\quad Z = 6$

5 electrons $\quad 1s^2\, 2s^2\, 2p\ {}^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 24.27 volts

The classification of this spectrum has been made by Fowler and Selwyn. The absolute value of the normal state, $2s^2\, 2p\ {}^2P_{\frac{1}{2}}^{\circ}$ has been given with respect to the ${}^1S_0$ of C III.

As there are no intercombinations between the doublet and quartet terms known, the absolute values of the quartet terms are given with respect to the $2s\, 2p\ {}^3P^{\circ}$ of C III from which they arise.

References

A. Fowler, *Proc. Roy. Soc.*, **A105**, 299 (1924).

I. S. Bowen, *Phys. Rev.* **29**, 231 (1927). Ultra-violet classified lines and term values.

A. Fowler and E. W. H. Selwyn, *Proc. Roy. Soc.*, **A120**, 312 (1928). Complete term tables and classified and unclassified lines.

Configuration	Symbol	J	Term value	$\Delta\nu$	
$2s^2\, 2p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*196659.0* *196595.0*	64.0	Asolute values with respect to $2s^2\ {}^1S_0$ of C III.
$2s\, 2p^2$	${}^2D$	$2\frac{1}{2}$ $1\frac{1}{2}$	121728.1 121726.9	−1.2	
$2s\, 2p^2$	${}^2S$	$1\frac{1}{2}$	100164.9		
$2s\, 2p^2$	${}^2P$	$\frac{1}{2}$ $1\frac{1}{2}$	86033.9 85992.7	41.2	
$2s^2\, 3s$	${}^2S$	$\frac{1}{2}$	80121.1		
$2s^2\, 3p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*64934.3* *64923.2*	11.1	
$2s^2\, 3d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	51109.0 51107.6	1.4	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^3$	$^2D^\circ$	$2\frac{1}{2}$ $1\frac{1}{2}$	*46196.2* *46191.1*	−5.1
$2s^2\ 4s$	^2S	$\frac{1}{2}$	39424.6	
$2s^2\ 4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*34140.3* *34134.4*	5.9
$2s^2\ 4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	28535.1 28534.7	0.4
$2s^2\ 4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*27680.0*	
$2s^2\ 5d$	^2D	$2\frac{1}{2}$	18164.2	
$2s^2\ 5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*17702.5*	
$2s^2\ 6d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	12558.0?	
$2s^2\ 6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*12282.8*	
$2s^2\ 7d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	9193.0?	

Configuration	Symbol	J	Term value	$\Delta\nu$	
$2s\ 2p^2$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	206810.7 206789.2 206760.6	21.5 28.6	Absolute values with respect to $2s\ 2p\ ^3P^\circ$ of CIII
$2p^3$	$^4S^\circ$	$1\frac{1}{2}$	*107788.1*		
$2s\ 2p\ (^3P)\ 3s$	$^4P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*82850.0* *82826.2* *82781.3*	23.8 44.9	
$2s\ 2p\ (^3P)\ 3p$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	68120.2 68105.5 68080.5 68044.2	14.7 25.0 36.3	
$2s\ 2p\ (^3P)\ 3p$	^4S	$1\frac{1}{2}$	65126.0		

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\,2p\,(^3P)\,3p$	^4P	$\frac{1}{2}$	63389.7	
		$1\frac{1}{2}$	63373.4	16.3
		$2\frac{1}{2}$	63351.0	22.4
$2s\,2p\,(^3P)\,3d$	$^4F^\circ$	$1\frac{1}{2}$	*54063.9*	
		$2\frac{1}{2}$	*54049.6*	14.3
		$3\frac{1}{2}$	*54030.0*	19.6
		$4\frac{1}{2}$	*54002.4*	27.6
$2s\,2p\,(^3P)\,3d$	$^4D^\circ$	$\frac{1}{2}$	*53258.5*	
		$1\frac{1}{2}$	*53252.9*	5.6
		$2\frac{1}{2}$	*53244.2*	8.7
		$3\frac{1}{2}$	*53233.9*	10.3
$2s\,2p\,(^3P)\,3d$	$^4P^\circ$	$2\frac{1}{2}$	*50972.7*	
		$1\frac{1}{2}$	*50951.2*	−21.5
		$\frac{1}{2}$	*50937.0*	−14.2
$2s\,2p\,(^3P)\,4s$	$^4P^\circ$	$\frac{1}{2}$	*40264.4*	
		$1\frac{1}{2}$	*40240.4*	24.0
		$2\frac{1}{2}$	*40194.3*	46.1
$2s\,2p\,(^3P)\,4p$	^4D	$\frac{1}{2}$	35056.4	
		$1\frac{1}{2}$	35042.1	14.3
		$2\frac{1}{2}$	35020.1	22.0
		$3\frac{1}{2}$	34986.7	36.4
$2s\,2p\,(^3P)\,4p$	^4S	$1\frac{1}{2}$	34049.1	
$2s\,2p\,(^3P)\,4d$	$^4P^\circ$	$2\frac{1}{2}$	*29006.2*	
		$1\frac{1}{2}$	*28985.7*	−20.5
		$\frac{1}{2}$	*28973.8*	−12.9

C III $Z = 6$

4 electrons $1s^2\ 2s^2\ {}^1S_0$

Ionization potential = 47.65 volts

These terms are from the unpublished work of B. Edlén. Absolute term values are well established for both the singlets and triplets and are given with respect to $2s\ {}^2S_{\frac{1}{2}}$ of C IV as zero. The triplets and singlets are given in separate tables, however, as intercombinations have not been observed.

References

I. S. Bowen, *Phys. Rev.* **38**, 128 (1931).
B. Edlén, unpublished material.

Configuration	Symbol	J	Term value
$2s^2$	${}^1S$	0	386159.7
$2s\ 2p$	${}^1P^{\circ}$	1	*283808.3*
$2p^2$	${}^1D$	2	240284.6
$2p^2$	${}^1S$	0	203639.8
$2s\ 3s$	${}^1S$	0	138991.2
$2s\ 3p$	${}^1P^{\circ}$	1	*127228.4*
$2s\ 3d$	${}^1D$	2	109676.5
$2p\ 3s$	${}^1P^{\circ}$	1	*76154.2*
$2s\ 4s$	${}^1S$	0	74439.0
$2p\ 3p$	${}^1D$	2	66440.3
$2s\ 4p$	${}^1P^{\circ}$	1	*63762.2*
$2s\ 4f$	${}^1F^{\circ}$	3	*63458.1*

CARBON III

(*Concluded*)

Configuration	Symbol	J	Term value
$2s\,4d$	^1D	2	61947.7
$2p\,3d$	$^1F^\circ$	3	*53470.0*
$2p\,3p$	^1P	1	53043.0
$2p\,3d$	$^1D^\circ$	2	*44791.5*
$2s\,5p$	$^1P^\circ$	1	*42904.0*
$2p\,3p$	^1S	0	41065.5
$2s\,5g$	^1G	4	39581.7
$2s\,5d$	^1D	2	39509.3
$2p\,3d$	$^1P^\circ$	1	*37300.2*
$2s\,6p$	$^1P^\circ$	1	*29055.1*
$2s\,6g$	^1G	4	27470.3
$2s\,6d$	^1D	2	27437.5
$2p\,4s$	$^1P^\circ$	1	*7128*
$2p\,4p$	^1D	2	5047
$2p\,4p$	^1P	1	506
$2p\,4d$	$^1F^\circ$	3	*338*
$2p\,5p$	^1P	1	−23364
$2p\,5d$	$^1F^\circ$	3	*−23526*

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\,2p$	$^3P^\circ$	0	*333844.6*	
				23.7
		1	*333820.9*	
				56.0
		2	*333764.9*	
$2p^2$	^3P	0	248784.9	
				28.9
		1	248756.0	
				46.8
		2	248709.2	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 3s$	^3S	1	147999.0	
$2s\ 3p$	$^3P^\circ$	0	*126505.9*	
				5.5
		1	*126500.4*	
				12.8
		2	*126487.6*	
$2s\ 3d$	^3D	1	116203.2	
				2.8
		2	116200.4	
				3.1
		3	116197.3	
$2p\ 3s$	$^3P^\circ$	0	*77997.9*	
				34.3
		1	*77963.6*	
				68.7
		2	*77894.9*	
$2s\ 4s$	^3S	1	76755.2	
$2s\ 4p$	$^3P^\circ$	0, 1, 2	*68415*	
$2s\ 4d$	^3D	1	64803.0	
				18.4
		2	64784.6	
				23.5
		3	64761.1	
$2s\ 4f$	$^3F^\circ$	2	*64210.3*	
				6.5
		3	*64203.8*	
				9.0
		4	*64194.8*	
$2p\ 3p$	^3D	1	63137.0	
				27.5
		2	63109.5	
				38.7
		3	63070.8	
$2p\ 3p$	^3S	1	58934.2	
$2p\ 3p$	^3P	0	56526.6	
				21.1
		1	56505.5	
				36.7
		2	56468.8	
$2p\ 3d$	$^3F^\circ$	2	*52827.8*	
				27.7
		3	*52800.1*	
				34.9
		4	*52765.2*	
$2p\ 3d$	$^3D^\circ$	1, 2	*48549.7*	
				25.0
		3	*48524.7*	
$2s\ 5s$	^3S	1	46259.9	

CARBON III

(*Concluded*)

Configuration	Symbol	J	Term Value	$\Delta\nu$
$2p\ 3d$	$^3P^\circ$	2 1 0	*46110.2* *46083.9* *46069.4*	−26.3 −14.5
$2s\ 5d$	^3D	1, 2, 3	40717	
$2s\ 5g$	^3G	3, 4, 5	39634.3	
$2s\ 5f$	$^3F^\circ$	2 3 4	*39061.5* *39057.6* *39055.3*	3.9 2.3
$2s\ 6d$	^3D	1, 2, 3	28117	
$2s\ 6g$	^3G	3, 4, 5	27523.4	
$2p\ 4p$	^3D	1, 2, 3	4237	
$2p\ 4p$	^3P	0, 1, 2	1844	
$2p\ 4d$	$^3D^\circ$	1, 2, 3	*−1473*	
$2p\ 5p$	^3D	1, 2, 3	−21586	
$2p\ 5p$	^3P	0, 1, 2	−22688	
$2p\ 5d$	$^3D^\circ$	1, 2, 3	*−24359*	
$2p\ 6p$	^3D	1, 2, 3	−35184	
$2p\ 6p$	^3P	0, 1, 2	−35743	
$2p\ 6d$	$^3D^\circ$	1, 2, 3	*−36728*	

C IV $Z = 6$

3 electrons $1s^2\ 2s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 64.22 volts

These term values of C IV are from unpublished data of B. Edlén.

References

B. Edlén and A. Ericson, *Zeits. f. Physik* **64**, 64 (1930).
B. Edlén and J. Stenman, *Zeits. f. Physik* **66**, 328 (1930).
B. Edlén, unpublished material.

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s$	^2S	$\frac{1}{2}$	520175.7	
$2p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*455691.5* *455584.4*	107.1
$3s$	^2S	$\frac{1}{2}$	217326.8	
$3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*200126.2* *200094.7*	31.5
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	195297.9 195286.6	11.3
$4s$	^2S	$\frac{1}{2}$	118828.0	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*111865.3* *111852.2*	13.1
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	109837.6	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*109743.7*	
$5s$	^2S	$\frac{1}{2}$	74809.3	
$5p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*71316.5*	
$5d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	70286.5	
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*70236.5*	
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	70229.4	
$6h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*48769.9*	

C V $\qquad$ $Z = 6$

2 electrons $\qquad$ $1s^2\ {}^1S_0$

Ionization potential = 389.9 ± 0.4 volts

Edlén found a resonance line in the extreme ultra-violet and obtained the absolute term values by extrapolating from other helium-like spectra.

Reference

B. Edlén, *Nature* **127**, 405 (1931).

Configuration	Symbol	J	Term value
$1s^2$	^1S	0	3159600 ± 3300
$1s\,2p$	$^1P^\circ$	1	*677000* ± 2000

Ca I $Z = 20$

20 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ {}^1S_0$

First ionization potential = 6.09 volts

The terms built on the $4s\ {}^2S_{\frac{1}{2}}$ of the ion can be found in Fowler and in Paschen-Götze; the terms built upon other states of the ion have been given originally by Russell and Saunders.

The first tables contain the low series members and all states involving two excited electrons. The later "series" tables give *all* the regular series terms.

The absolute values of all terms have been given with respect to the $4s\ {}^2S_{\frac{1}{2}}$ of Ca II.

References

H. N. Russell and F. A. Saunders, *Astrophys. Journ.* **61**, 38 (1925). Irregular terms.

H. N. Russell, *Astrophys. Journ.* **66**, 191 (1927). Additional assignments.

E. Back, *Zeits. f. Physik* **33**, 579 (1925). Zeeman effect.

Russell-Saunders notation	Configuration	Symbol	J	Term value	$\Delta\nu$
$1S$	$4s^2$	${}^1S$	0	49304.8	
$1p_3$	$4s\ 4p$	${}^3P^\circ$	0	*34146.9*	52.3
$1p_2$			1	*34094.6*	105.9
$1p_1$			2	*33988.7*	
$1d_3$	$4s\ 3d$	${}^3D$	1	28969.1	13.9
$1d_2$			2	28955.2	21.7
$1d_1$			3	28933.5	
$1D$	$4s\ 3d$	${}^1D$	2	27455.3	
$1P$	$4s\ 4p$	${}^1P^\circ$	1	*25652.4*	

(*Continued*)

Russell-Saunders notation	Configuration	Symbol	J	Term value	$\Delta\nu$	
W	—	1°	2 or 3	*17973.8*		
$1s$	$4s\ 5s$	^3S	1	17765.1		
$2s$	$4s\ 5s$	^1S	0	15988.2		
q	—	2	1 or 2	15818.3		
$1f_3''$	$3d\ 4p$	$^3F^\circ$	2	*13573.9*	88.0	
$1f_2''$			3	*13485.9*	78.3	
$1f_1''$			4	*13407.6*		
x	—	3°	2	*13469.1*		$3d\ 4p\ ^1D_2^\circ$
$2p_3$	$4s\ 5p$	$^3P^\circ$	0	*12752.5*	2.3	
$2p_2$			1	*12750.2*	19.9	
$2p_1$			2	*12730.3*		
$2P$	$4s\ 5p$	$^1P^\circ$	1	*12573.1*		$3d\ 4p\ ^1P_1^\circ$
$2D$	$4s\ 4d$	^1D	2	12006.3		
$2d_3$	$4s\ 4d$	^3D	1	11556.4	3.8	
$2d_2$			2	11552.6	5.6	
$2d_1$			3	11547.0		
$1d_3'$	$3d\ 4p$	$^3D^\circ$	1	*11112.0*	26.7	
$1d_2'$			2	*11085.3*	40.0	
$1d_1'$			3	*11045.3*		
$1p_3'$	$4p^2$	^3P	0	10887.1	47.3	
$1p_2'$			1	10839.8	86.8	
$1p_1'$			2	10753.0		
$1p_3''$	$3d\ 4p$	$^3P^\circ$	0	*9971.0*	1.9	
$1p_2''$			1	*9969.1*	4.8	
$1p_1''$			2	*9964.3*		
Y	—	4°	2 or 3	*8767.0*		$3d\ 4p\ ^1F^\circ$
Z	—	5	0 or 1 or 2	8614.2		$4p^2\ ^1S_0$
X	—	6	2 or 1	8584.9		$4p^2\ ^1D_2$

(*Concluded*)

Russell-Saunders notation	Configuration	Symbol	J	Term value	$\Delta\nu$
$3f_3\ 3f_2\ 3f_1$	$4s\ \ 4f$	$^3F^\circ$	2, 3, 4	*7133.9*	
$3F$	$4s\ \ 4f$	$^1F^\circ$	3	*6961.3*	
$4f_3\ 4f_2\ 4f_1$	$4s\ \ 5f$	$^3F^\circ$	2, 3, 4	*4541.5*	
$4F$	$4s\ \ 5f$	$^1F^\circ$	3	*4500.0*	
$2p_3'$	$3d^2$	^3P	0	780.6	
$2p_2'$			1	767.1	13.5
$2p_1'$			2	741.1	26.0
$2d_3'$	$3d\ \ 5p$	$^3D^\circ$	1	*−2406.5*	
$2d_2'$			2	*−2429.8*	23.3
$2d_1'$			3	*−2462.2*	32.4
q_1	—	7°	1	*−2065.8*	
q_2	—	8	1	−2266.9	$3d\ \ 4d\ \ ^3S_1$
q_8	—	9°	2 or 3 or 4	*−2389.0*	
q_7	—	10°	2 or 3 or 4	*−3673.6*	
$3p_3'$	$3d\ \ 4d$	^3P	0	−4977.5	
$3p_2'$			1	−4983.6	6.1
$3p_1'$			2	−4999.8	16.2
q_6	—	11	2 or 3 or 4	−6252.8	
q_3	—	12	1 or 2	−7164.2	
q_4	—	13	1	−7254.1	
$4p_3'$	$3d\ \ 5d$	^3P	0	−8306.4	
$4p_2'$			1	−8313.1	6.7
$4p_1'$			2	−8333.6	20.5
$5p_3'$	$3d\ \ 6d$	^3P	0	—	
$5p_2'$			1	−10063.0	
$5p_1'$			2	−10086.0	23.0

SERIES

4s ms			
m	$^3S_1$	m	$^1S_0$
4		4	49304.8
5	17765.1	5	15988.2
6	8830.3	6	7518.4
7	5323.8	7	5028.0
8	3565.6	8	3417.3
9	2556.2	9	2469.4
10	1922.4	10	1867.7
11	1498.6	11	1461.5
12	1200.3	12	1176.0
13	982.5		
14	819.8		

4s mp					
m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	m	$^1P_1^\circ$
4	*34146.9*	*34094.6*	*33988.7*	4	*25652.4*
5	*12752.5*	*12750.2*	*12730.3*	5	*12573.1*
				6	*7625.9*
				7	*5371.4*
				8	*3879.6*
				9	*2824.6*
				10	*2120.3*
				11	*1638.2*
				12	*1305.9*
				13	*1071.6*
				14	*888.5*

SERIES (*Concluded*)

4s *md*

m	$^3D_1$	$^3D_2$	$^3D_3$	m	$^1D_2$
3	28969.1	28955.2	28933.5	3	27455.3
4	11556.4	11552.6	11547.0	4	12006.3
5	6561.4	6559.7	6556.9	5	6385.5
6	4255.5	4254.0	4252.2	6	4314.7
7	3002.4	3000.6	2998.2	7	2994.7
8	2268.2	2264.5	2259.3		
9	1848.9	1838.7	1828.8		
10	1551.2	1547.0	1539.1		
11	1272.7	1270.7	1268.2		

$m = 12$	1045.4	$m = 15$	627.9
$m = 13$	869.6	$m = 16$	541.0
$m = 14$	733.8	$m = 17$	473.5

4s *mf*

m	$^3F^\circ_{2,3,4}$	m	$^1F^\circ_3$
4	*7133.9*	4	*6961.3*
5	*4541.5*	5	*4500.3*
6	*3139.5*	6	*3122.6*
7	*2298.1*	7	*2289.7*
8	*1754.1*	8	*1749.8*
9	*1382.3*	9	*1379.8*
10	*1117.7*	10	*1116.3*
11	*923.0*	11	*919.3*
12	*774.0*		
13	*660.0*		

3d *md*

m	$^3P_0$	$^3P_1$	$^3P_2$
3	780.6	767.1	741.1
4	−4977.5	−4983.6	−4999.8
5	−8306.4	−8313.1	−8333.6
6		−10063.0	−10086.0

Ca II $Z = 20$

19 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 11.82 volts

The classification of Ca II has been extended by Saunders and Russell. The absolute values are given with respect to the $3p^6\ {}^1S_0$ of Ca III.

References

F. A. Saunders and H. N. Russell, *Astrophys. Journ.* **62**, 1 (1925). Classified lines and terms in series form.

H. N. Russell, *Astrophys. Journ.* **66**, 283 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^6$ $4s$	^2S	$\frac{1}{2}$	95748.0	
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	82097.8 82037.0	60.8
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*70556.4* *70333.6*	222.8
$5s$	^2S	$\frac{1}{2}$	43581.0	
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	38908.7 38889.6	19.1
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*35213.4* *35135.0*	78.4
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*27694.0*	
$6s$	^2S	$\frac{1}{2}$	25070.3	
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	23026.0 23017.3	8.7
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*21262.2* *21226.3*	35.9

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^6\ 5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*17714.1*	
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	—	
$7s$	^2S	$\frac{1}{2}$	16298.3	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	15224.8 15220.0	4.8
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*12290.0*	
$6g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	12211.0	
$8s$	^2S	$\frac{1}{2}$	11445.7	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	10812.8 10809.8	3.0
$7f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*9022.0*	
$7g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	8970.1	
$8d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	8074.2 8072.4	1.8
$8g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	6867.2	
$9d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	6258.5 6257.2	1.3
$9g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	5424.6	
$10d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	4993.1 4992.1	1.0

Ca III $\qquad$ $Z = 20$

18 electrons $\qquad$ $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\;{}^1S_0$

First ionization potential = 51.0 volts

The classification of Ca III has been given by Bowen.

The absolute value of the lowest term $3p^6\;{}^1S_0$ is given as 413127 cm.$^{-1}$ with respect to the $3p^5\;{}^2P_{1\frac{1}{2}}^\circ$ of Ca IV.

For the notation see Ne I.

Reference

I. S. Bowen, *Phys. Rev.* **31**, 497 (1928).

Paschen notation	Configuration	Symbol	J	Term value
$1p$	$3p^6$	${}^1S$	0	0.0
$3d_6$	$3p^5\,({}^2P_{1\frac{1}{2}})\,3d$	1°	0	—
$3d_5$		2°	1	*203845.1*
$3d_3$		3°	2	*204835.4*
$3d_4'$		4°	4	—
$3d_4$		5°	3	*213378.3*
$3d_1''$		6°	2	*214332.3*
$3d_1'$		7°	3	—
$3d_2$		8°	1	*224552.4*
$3s_1''''$	$3p^5\,({}^2P_{\frac{1}{2}})\;3d$	9°	1 or 2	*225823.2*
$3s_1''$		10°	2	*227387.8*
$3s_1'''$		11°	3	*228411.6*
$3s_1'$		12°	1	*232831.4*
$1s_5$	$3p^5\,({}^2P_{1\frac{1}{2}})\;4s$	1°	2	*242543.5*
$1s_4$		2°	1	*243927.0*
$1s_3$	$3p^5\,({}^2P_{\frac{1}{2}})\;4s$	3°	0	*245608.4*
$1s_2$		4°	1	*247693.4*

(*Concluded*)

Paschen notation	Configuration	Symbol	J	Term value
$2p_{10}$	$3p^5\ (^2P_{1\frac{1}{2}})\ 4p$	1	1	272185.4
$2p_9$		2	3	277018.8
$2p_8$		3	2	277377.5
$2p_7$		4	1	278616.7
$2p_6$		5	2	279738.2
$2p_5$		6	0	282072.0
$2p_4$	$3p^5\ (^2P_{\frac{1}{2}})\ 4p$	7	1	281136.3
$2p_3$		8	2	281878.8
$2p_2$		9	1	282568.4
$2p_1$		10	0	—
$4D_1$	$3p^5\ (^2P_{1\frac{1}{2}})\ 4d$	2°	1	*322998.9*
$4D_2$		3°	2	*323650.6*
$4D_3$		5°	3	*326182.0*
$4D_4$		6°	2	*328086.5*
$4D_5$	$3p^5\ (^2P_{\frac{1}{2}})\ 4d$	11°	3	*335285.9*
$2s_5$	$3p^5\ (^2P_{1\frac{1}{2}})\ 5s$	1°	2	*327917.0*
$2s_4$		2°	1	*328580.4*
$2s_3$	$(3p^5\ ^2P_{\frac{1}{2}})\ 5s$	3°	0	*331042.7*
$2s_2$		4°	1	*331398.6*

Ca IV $\quad Z = 20$

17 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^5\; {}^2P^{\circ}_{1\frac{1}{2}}$

The following terms for Ca IV have been found by Bowen in a study of a group of isoelectronic spectra in the ultra-violet.

Reference

I. S. Bowen, *Phys. Rev.* **31**, 497 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\, 3p^5$	${}^2P^{\circ}$	$1\frac{1}{2}$	*0*	
		$\frac{1}{2}$	*3130*	-3130
$3s\;\; 3p^6$	${}^2S$	$\frac{1}{2}$	152450	
$3s^2\, 3p^4\, 4s$	${}^2P$?	$1\frac{1}{2}$ or $\frac{1}{2}$	298187	

Ca V $Z = 20$

16 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^4\;{}^3P_2$

The classification of Ca V has been given by Bowen in a study of isoelectronic spectra in the far ultra-violet.

Reference

I. S. Bowen, *Phys. Rev.* **31**, 497 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^4$	^3P	2	0	
				−2402
		1	2402	
				−869
		0	3271	
$3s\;3p^5$	$^3P^\circ$	2	*154678*	
				−2088
		1	*156766*	
				−1133
		0	*157899*	

Cb I $\qquad Z = 41$

51 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^4\, 5s\ {}^6D$

Meggers has given many of the sextet terms of the columbium arc spectrum but none of the quartet or doublet terms have been found. Probably all the terms are built upon the two low terms of Cb II which are close to each other, $4d^4\ {}^5D$ and $4d^3\ 5s\ {}^5F$. The highest multiplet of the group, a ${}^6P°$ is difficult to place.

For odd terms the division into multiplets is rather uncertain because of the overlapping. This also causes difficulties in determining the assignment of electron configurations.

References

W. F. Meggers, *Journ. Wash. Acad. Sci.* **14,** 442 (1924).
W. F. Meggers and C. C. Kiess, *Journ. Opt. Soc. Am.* **12,** 417 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^4\ ({}^5D)\ 5s$	${}^6D$	½	0	
		1½	154.3	154.3
		2½	392.0	237.7
		3½	695.3	303.3
		4½	1050.4	355.1
$4d^4\ ({}^5D)\ 5p$?	${}^6F°$	1½	*23984.8*	
		2½	*24164.6*	179.8
		3½	*24396.7*	232.1
		4½	*24769.6*	372.9
		5½	*25199.8*	430.2
		6½	*25690.2*	490.4
$4d^4\ ({}^5D)\ 5p$?	${}^6P°$	1½	*24283.3*	
		2½	*24543.1*	259.8
		3½	*24904.8*	361.9
$4d^4\ ({}^5D)\ 5p$?	${}^6D°$	½	*26552.3*	
		1½	*26713.2*	160.9
		2½	*26983.2*	270.0
		3½	*27427.0*	443.8
		4½	*27974.8*	547.8

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$^6D°$	½	*28007.2 ?*	
		1½	*28208.5*	201.3
		2½	*28445.7*	237.2
		3½	*28549.6*	103.9
		4½	*29175.1*	625.5
—	$^6P°$	1½	*28278.4*	
		2½	*28652.7*	374.3
		3½	*28973.4*	320.7

Cb II $Z = 41$

40 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^4\;{}^5D_0$

These terms are taken from a paper by Meggers and Kiess. The odd multiplets overlap and their assignment, therefore, seems rather uncertain.

Reference

W. F. Meggers and C. C. Kiess, *Journ. Opt. Soc. Am.* **12**, 417 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^4$	^5D	0	0	
				159.0
		1	159.0	
				279.6
		2	438.6	
				362.8
		3	801.4	
				423.6
		4	1225.0	
$4d^3\,(^4F)\,5s$	^5F	1	2356.9	
				272.3
		2	2629.2	
				401.0
		3	3030.2	
				512.9
		4	3543.1	
				603.6
		5	4146.7	
$4d^3\,(^4F)\,5p$	$^5G^\circ$	2	*33351.6*	
				568.0
		3	*33919.6*	
				713.1
		4	*34632.7*	
				842.3
		5	*35475.0*	
				980.8
		6	*36455.8*	
—	$^5F^\circ$	1	*36731.8*	
				231.2
		2	*36963.0*	
				414.0
		3	*37377.0*	
				151.7
		4	*37528.7*	
				495.7
		5	*38024.4*	
—	$^5D^\circ$	0	*37298.5*	
				182.2
		1	*37480.7*	
				316.8
		2	*37797.5*	
				418.8
		3	*38216.3*	
				75.0
		4	*38291.3*	

Cb III $\qquad Z = 41$

39 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^2\,5s\;{}^4F_{1\frac{1}{2}}$

Ionization potential = 24.2 volts

The classification of this spectrum has been made by Gibbs and White. They give the absolute value of the lowest state as 196,296.4 cm.$^{-1}$ with respect to $4d^2\;{}^3F_2$ of Cb IV.

Reference

R. C. Gibbs and H. E. White, *Phys. Rev.* **31**, 520 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\,(^3F)\,5s$	^4F	$1\frac{1}{2}$	0	
		$2\frac{1}{2}$	515.3	515.3
		$3\frac{1}{2}$	1243.7	728.9
		$4\frac{1}{2}$	2153.5	909.8
$5p$	$^4G^\circ$	$2\frac{1}{2}$	*38466.2*	
		$3\frac{1}{2}$	*39785.9*	1319.7
		$4\frac{1}{2}$	*41235.3*	1449.4
		$5\frac{1}{2}$	*42840.5*	1605.2
$5p$	$^4F^\circ$	$1\frac{1}{2}$	*41276.8*	
		$2\frac{1}{2}$	*41874.0*	597.2
		$3\frac{1}{2}$	*42647.5*	773.5
		$4\frac{1}{2}$	*43566.6*	919.1
$5p$	$^4D^\circ$	$\frac{1}{2}$	*43962.7*	
		$1\frac{1}{2}$	*44452.7*	490.0
		$2\frac{1}{2}$	*45059.8*	607.1
		$3\frac{1}{2}$	*45366.8*	307.0

Cb IV $Z = 41$

38 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^2\ {}^3F_2$

The classification has been made by Gibbs and White. The lowest state has not been found. The absolute value of the $4d\,5s\ {}^3D_1$ state is given as 292520 cm.$^{-1}$ with respect to $4d\ {}^2D_{1\frac{1}{2}}$ of Cb V.

Reference

R. C. Gibbs and H. E. White, *Phys. Rev.* **31**, 520 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\,5s$	^3D	1	0	
		2	565.5	565.5
		3	1746.2	1180.7
$5p$	$^3D^\circ$	1	*46927.8*	
		2	*48325.7*	1397.9
		3	*49714.1*	1388.4
$5p$	$^3F^\circ$	2	*47660.4*	
		3	*48321.8*	661.4
		4	*50931.0*	2609.2

Cd I $\qquad Z = 48$

48 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ {}^1S_0$

First ionization potential = 8.96 volts

This classification can be found in Paschen-Götze and Fowler. The $p^2\ {}^3P$ and several higher series members were added by Ruark.

Schüler and Brück succeeded in interpreting the hyperfine structure of several lines and showed that it was caused by two groups of isotopes, one group with a nuclear moment $I = \frac{1}{2}$, the other group with $I = 0$. The hyperfine structures are inverted, as if they were caused by the magnetic moment of negative particles inside of the nucleus. The level separations of the isotopes with $I = \frac{1}{2}$ are:

	cm.$^{-1}$
$5s\ 6s\ {}^3S_1$	−0.379
$7s\ {}^3S_1$	−0.369
$8s\ {}^3S_1$	−0.354
$5s\ 5p\ {}^3P_1$	−0.210
${}^3P_2$	−0.281
$5s\ 5d\ {}^3D_1$	+0.184
${}^3D_3$	−0.281

References

A. E. Ruark, *Journ. Opt. Soc. Am.* **11**, 199 (1925).

H. Schüler and H. Brück, *Zeits. f. Physik* **56**, 291 (1929); **58**, 735 (1929).

C. L. Albright, *Phys. Rev.* **36**, 847 (1930).

S. Goudsmit, *Naturwiss.* **17**, 805 (1929).

H. Schüler and J. E. Keyston, *Zeits. f. Physik* **67**, 433 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	${}^1S$	0	72538.8	
$5s\ 5p$	${}^3P^\circ$	0	*42424.5*	
				541.9
		1	*41882.6*	
				1171.1
		2	*40711.5*	

CADMIUM I

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\ 5p$	$^1P^\circ$	1	*28846.6*	
$5s\ 6s$	^3S	1	21054.7	
$5s\ 6s$	^1S	0	19229.3	
$5s\ 6p$	$^3P^\circ$	0 1 2	*14147.9* *14077.2* *13903.1*	70.7 174.1
$5s\ 5d$	^1D	2	13319.2	
$5s\ 5d$	^3D	1 2 3	13052.4 13040.7 13022.5	11.7 18.2
$5s\ 6p$	$^1P^\circ$	1	*12633.2*	
$5s\ 7s$	^3S	1	9975.6	
$5s\ 7s$	^1S	0	9452.1	
$5s\ 7p$	$^3P^\circ$	0 1 2	*7542.9* *7517.5* *7446.0*	25.4 71.5
$5s\ 6d$	^1D	2	7404.9	
$5s\ 6d$	^3D	1 2 3	7185.3 7179.5 7171.3	5.8 8.2
$5s\ 7p$	$^1P^\circ$	1	*7044.6*	
$5s\ 4f$	$^3F^\circ$	2, 3, 4	*6957.1*	

$5p^2$	^3P	0 1 2	−1458 −2207 —	749

SERIES

5s ms

m	$^3S_1$	$^1S_0$
5		72538.8
6	21054.7	19229.3
7	9975.6	9452.1
8	5857.3	5634.1
9	3856.6	3739.2
10	2732.9	2665.7
11	2037.6	1995.6
12	1576.8	1546.7
13	1257.0	1239.8
14	1023.2	1010.8
15	849.2	846.4

5s mp

m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	$^1P_1^\circ$
5	*42424.5*	*41882.6*	*40711.5*	*28846.6*
6	*14147.9*	*14077.2*	*13903.1*	*12633.2*
7	*7542.9*	*7517.5*	*7446.0*	*7044.6*
8	*4709.2*	*4696.7*	*4663.6*	*4483.4*
9	*3224.3*	*3217.4*	*3198.6*	*3103.1*
10	*2331.5*	*2331.5*	*2331.5*	*2276.2*
11				*1738.8*
12				*1380.9* ?

5s md

m	$^3D_1$	$^3D_2$	$^3D_3$	$^1D_2$
5	13052.4	13040.7	13022.5	13319.2
6	7185.3	7179.5	7171.3	7404.9
7	4549.9	4546.3	4541.3	4701.7
8	3139.2	3138.5	3134.5	3246.3
9		2294.5		2362.9
10		1751.3		1796.9
11		1379.3		1419.3
12		1114.3		
13		920.3		942.5
14		771.6		782.7
15		658.1		669.6
16		566.7		
17		492.1		
18		430.6		
19		383.1		

5s mf

m	$^3F^\circ_{2,3,4}$
4	*6957.1*
5	*4445.1*

Cd II $Z = 48$

47 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 16.84 volts

These term values are taken from a paper by Takahashi. The first table gives the low terms only, the second one contains the rest of the *irregular* terms. The remaining tables give the terms which form series.

Reference

Y. Takahashi, *Ann. d. Physik* **3**, 27 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^{10}\ 5s$	^2S	$\frac{1}{2}$	136376.6	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*92241.3* *89758.1*	2483.2
$4d^9\ 5s^2$	^2D	$2\frac{1}{2}$ $1\frac{1}{2}$	67117.8 61483.0	−5734.8
$4d^{10}\ 6s$	^2S	$\frac{1}{2}$	53386.4	
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	46685.3 46531.0	454.3
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*41665.8* *40992.5*	673.3
—	1°	$1\frac{1}{2}$ or $2\frac{1}{2}$	*29817.0*	
$7s$	^2S	$\frac{1}{2}$	29077.1	
$4f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*27955.1* *27942.3*	12.8
—	2° 3°	$1\frac{1}{2}$ $1\frac{1}{2}$ or $2\frac{1}{2}$	*26936.9* *26208.9*	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	26202.1 26128.6	73.5

(*Concluded*)

Configuration	Symbol	J	Term value	
—	4°	1½ or 2½	*24018.1*	
	5°	2½ ?	*23309.0*	
	6°	1½	*21647.5*	
	7°	1½ or 2½	*21426.0*	
	8°	1½	*20151.4*	
	9°	1½	*19423.5*	
	10°	½ or 1½	*18382.3*	
	11°	1½	*17319.8*	
	12°	1½	*16240.0*	
	13°	1½ or 2½	*15093.5*	
	14°	1½	*8378.8*	
	15°	1½ or 2½	*6696.8*	
	16	1½ or 2½	−11961.2	
	17	½ or 1½	−12204.0	
	18	?	−13052.1	
	19	1½ or 2½	−13122.3	
	20	1½ ?	−13167.0	
	21	?	−15256.8	
	22	?	−15986.8	
	23	?	−16445.7	
	24	?	−17227.8	
	25	1½ or 2½	−21051.7	
	26	½ or 1½	−21206.9	
	27	?	−21482.4	
	28	?	−21914.5	
	29	?	−23549.0	
	30	?	−24950.9	
	31	1½ or 2½	−26683.8	
	32	?	−26802.0	

SERIES

ms	
m	$^2S_{\frac{1}{2}}$
5	136376.6
6	53386.4
7	29077.1
8	18335.5
9	12624.3
10	9223.2
11	7033.8
12	5540.6

mp		
m	$^2P_{\frac{1}{2}}^{\circ}$	$^2P_{1\frac{1}{2}}^{\circ}$
5	*92241.3*	*89758.1*
6	*41665.8*	*40992.5*
7	*24001.7*	*23886.3*
8	*15722.4*	*15668.0*
9	*11151.4*	*11119.8*

md		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
5	46685.3	46531.0
6	26202.1	26128.6
7	16854.0	16814.2
8	11762.4	11738.9
9	8678.8	8663.9
10	6667.6	6657.7
11	5275.8	5283.3

mf		
m	$^2F_{2\frac{1}{2}}^{\circ}$	$^2F_{3\frac{1}{2}}^{\circ}$
4	*27955.1*	*27942.3*
5	*17828.7*	unres.
6	*12386.8*	*12403.0*
7	*9092.5*	*9126.5*
8	*6957.5*	

mg	
m	$^2G_{3\frac{1}{2},4\frac{1}{2}}$
5	12223.2
6	8977.9
7	6872.1

Cd III $\qquad Z = 48$

46 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\ {}^1S_0$

Ionization potential = 35 volts

The classification of this spectrum has been made by Gibbs and White, by comparison with isoelectronic spectra. It has been given independently by McLennan, McLay, and Crawford.

The absolute value of the lowest term is given as approximately 42050 cm.$^{-1}$ with respect to $4d^9\ {}^2D_{2\frac{1}{2}}$ of Cd IV.

References

R. C. Gibbs and H. E. White, *Phys. Rev.* **31,** 776 (1928).

J. C. McLennan, A. B. McLay, and M. F. Crawford, *Trans. Roy. Soc. Can.* **22,** 45 (1928).

Configuration	Symbol	J	Term value	Remarks
$4d^{10}$	^1S	0	0	
$4d^9\ (^2D_{2\frac{1}{2}})\ 5s$	1	3	80463.2	$^3D_3$
	2	2	82363.3	$^3D_2$
$(^2D_{1\frac{1}{2}})\ 5s$	3	1	86229.3	$^3D_1$
	4	2	88881.7	$^1D_2$
$4d^9\ (^2D)\ \ 5p$	1°	2	*133823*	$^3P_2$
	2°	3	*136224*	$^3F_3$
	3°	1	*138765*	$^3P_1$
	4°	4	*139042*	$^3F_4$
	5°	2	*140441*	$^3D_2$
	6°	2	*142123*	$^3P_0$
	7°	0	*142765*	$^2F_2$
	8°	3	*142905*	$^3D_3$
	9°	1	*146085*	$^1P_1$
	10°	3	*146101*	$^1F_3$
	11°	1	*147637*	$^3D_1$
	12°	2	*148475*	$^1D_2$

Ce IV $\quad Z = 58$

55 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s^2\,5p^6\,4f\ {}^2F_{2\frac{1}{2}}$

Several lines of the Ce IV spectrum have been recognized by Gibbs and White and by Badami. The lowest state has not been found.

References

R. C. Gibbs and H. E. White, *Phys. Rev.* **33**, 159 (1929).
J. S. Badami, *Proc. Phys. Soc. Lond.* **43**, 53 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d$	${}^2D$	$1\frac{1}{2}$	0	3304.9
		$2\frac{1}{2}$	3304.9	
$6s$	${}^2S$	$\frac{1}{2}$	5151.6	
$6p$	${}^2P^\circ$	$\frac{1}{2}$	*41135.3*	4706.9
		$1\frac{1}{2}$	*45842.2*	
$6d$	${}^2D$	$2\frac{1}{2}$	97111.4	

Cl I $Z = 17$

17 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^5\;{}^2P_{1\frac{1}{2}}^{\circ}$

First ionization potential = 12.96 volts

The classification is taken from Kiess and De Bruin. They have estimated the absolute value of the lowest state to be 104991 cm.$^{-1}$ referred to $3p^4\;{}^3P_2$ of Cl II. The terms whose multiplet character has been recognized are all built upon this state of Cl II.

References

K. Majumdar, *Proc. Roy. Soc.* **A125,** 60 (1925).
C. C. Kiess and T. L. De Bruin, *Bur. Stand. Journ. Res.* **2,** 1117 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^5$	${}^2P^{\circ}$	$1\frac{1}{2}$ $\frac{1}{2}$	*0* *881*	−881
$3p^4\,({}^3P)\,4s$	${}^4P$	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	71954.00 72484.20 72822.64	−530.20 −338.44
$3p^4\,({}^3P)\,4s$	${}^2P$	$1\frac{1}{2}$ $\frac{1}{2}$	74221.44 74861.24	−639.80
$3p^4\,({}^3P)\,4p$	${}^4P^{\circ}$	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*82914.54* *83126.59* *83360.55*	−212.05 −233.96
$3p^4\,({}^3P)\,4p$	${}^4D^{\circ}$	$3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*83889.64* *84127.90* *84480.91* *84684.27*	−238.26 −353.01 −203.36
$3p^4\,({}^3P)\,4p$	${}^2D^{\circ}$	$2\frac{1}{2}$ $1\frac{1}{2}$	*84643.69* *84984.04*	−340.35
$3p^4\,({}^3P)\,4p$	${}^2P^{\circ}$	$1\frac{1}{2}$ $\frac{1}{2}$	*85438.04* *85913.44*	−475.40

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	1		84115.68	
	2		84117.38	
	3		84120.46	
$3p^4\,(^3P)\,4p$	$^4S°$	$1\frac{1}{2}$	*85730.68*	
$3p^4\,(^3P)\,4p$	$^2S°$	$\frac{1}{2}$	*85879.72*	
—	4°		*94309.67*	
$3p^4\,(^3P)\,5p$	$^4P°$	$2\frac{1}{2}$	*94477.93*	
		$1\frac{1}{2}$	*94659.28*	−181.35
		$\frac{1}{2}$	*94969.43*	−310.15
$3p^4\,(^3P)\,5p$	$^4D°$	$3\frac{1}{2}$	*94727.91*	
		$2\frac{1}{2}$	*94822.75*	−94.84
		$1\frac{1}{2}$	*95309.43*	−486.68
		$\frac{1}{2}$	*95530.51*	−221.08
$3p^4\,(^3P)\,5p$	$^2D°$	$2\frac{1}{2}$	*95396.31*	
		$1\frac{1}{2}$	*95702.01*	−305.70
—	5°		*95593.28*	
$3p^4\,(^3P)\,5p$	$^4S°$	$1\frac{1}{2}$	*95608.30*	
$3p^4\,(^3P)\,3d$	^4D	$3\frac{1}{2}$	95696.49	
		$2\frac{1}{2}$	95782.41	−85.92
		$1\frac{1}{2}$	95893.16	−110.75
		$\frac{1}{2}$	95991.18	−98.02
$3p^4\,(^3P)\,5p$	$^2P°$	$1\frac{1}{2}$	*96308.84*	
		$\frac{1}{2}$	*96589.64*	−280.80
$3p^4\,(^3P)\,5p$	$^2S°$	$\frac{1}{2}$	*96481.63*	
—	6° ?		*96716.35?**	
$3p^4\,(^3P)\,3d$	^4F	$4\frac{1}{2}$		
		$3\frac{1}{2}$	97334.60	
		$2\frac{1}{2}$	97529.85	−195.25
		$\frac{1}{2}$		

* This term is given as an odd as well as an even term.

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^4\ (^3P)\ 6s$	^4P	$2\frac{1}{2}$	97233.37	
				−242.83
		$1\frac{1}{2}$	97476.20	
				−619.76
		$\frac{1}{2}$	98095.96	
$3p^4\ (^3P)\ 4d$	^4D	$3\frac{1}{2}$	99196.02	
				−68.69
		$2\frac{1}{2}$	99264.71	
				−85.51
		$1\frac{1}{2}$	99350.22	
				−53.39
		$\frac{1}{2}$	99403.61	
—	7		99984.12	
	8		100142.41	
$3p^4\ (^3P)\ 4d$	^4F	$4\frac{1}{2}$		
		$3\frac{1}{2}$	100985.60	
				−62.87
		$2\frac{1}{2}$	101048.47	
		$\frac{1}{2}$		

Cl II $\qquad Z = 17$

16 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^4\ {}^3P_2$

The classification of the triplets of Cl II has been given by Bowen on the basis of observations in the far ultra-violet. Paschen has given a classification of the quintets, but no inter-combinations have been found, so the terms are given in separate tables.

References

I. S. Bowen, *Phys. Rev.* **31**, 34 (1928). Classified lines; triplets.
F. Paschen, *Ann. d. Physik* **71**, 559 (1923). Quintets.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^4$	^3P	2	0.0	
				−694.0
		1	694.0	
				−300.0
		0	994.0	
$3s\,3p^5$	$^3P^\circ$	2	*93367.3*	
				−632.7
		1	*94000.0*	
				−331.0
		0	*94331.0*	
$3s^2\,3p^3\,4s$	$^3S^\circ$	1	*112606.0*	
$3s^2\,3p^3\,3d$	$^3D^\circ$	1	*126723.0*	
				21.0
		2	*126744.0*	
				40.0
		3	*126784.0*	
—	$^3D^\circ$	1	*140737.4*	
				271.7
		2	*141009.1*	
				343.9
		3	*141353.0*	
—	$^3P^\circ$	2	*157077.0*	
				−588.0
		1	*157665.0*	
				−291.0
		0	*157956.0*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^3\ (^4S)\ 4s$	$^5S^\circ$	2	*0.0*	
$3p^3\ (^4S)\ 3d$	$^5D^\circ$	4	*2417.1*	
				−0.9
		3	*2418.0*	
				−2.8
		2	*2420.8*	
				−3.0
		1	*2423.8*	
				−1.4
		0	*2325.2*	
$3p^3\ (^4S)\ 4p$	^5P	1	20743.5	
				40.5
		2	20784.0	
				67.2
		3	20851.2	
$3p^3\ (^4S)\ 5s$	$^5S^\circ$	2	*44355.4*	
—	$^5D^\circ$	0	*46738.5*	
				1.0
		1	*46739.5*	
				1.9
		2	*46741.4*	
				2.6
		3	*46744.0*	
				1.1
		4	*46745.1*	

Cl III $Z = 17$

15 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^3\;{}^4S_{1\frac{1}{2}}^{\circ}$

First ionization potential = 39.7 volts

The classification of Cl III has been given by Bowen and is based for the most part on observations in the ultra-violet. According to the classification no intercombinations have been found, so the doublet terms are given in a separate table. The $3d\;{}^4P$ has been added by Gilles, the $4d\;{}^4F$ by Majumdar and Deb.

The absolute value of the lowest state, $3s^2\,3p^3\;{}^4S^{\circ}$, has been given as 321936 cm.$^{-1}$ with respect to the $3p^2\;{}^3P_0$ of Cl IV and has been determined by applying series extrapolation to $3s^2\,3p^2\;ms\;{}^4P_{\frac{1}{2}}$ terms.

References

I. S. Bowen, *Phys. Rev.* **31**, 34 (1928). Quartet terms and classified lines.
J. Gilles, *Comptes Rendus* **188**, 1158 (1929).
K. Majumdar and S. C. Deb, *Indian Journ. Phys.* **3**, 445 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^3$	${}^4S^{\circ}$	$1\frac{1}{2}$	0	
$3s\;3p^4$	${}^4P$	$2\frac{1}{2}$	98520.0	
				−610.0
		$1\frac{1}{2}$	99130.0	
				−345.0
		$\frac{1}{2}$	99475.0	
$3s^2\,3p^2\,({}^3P)\,4s$	${}^4P$	$\frac{1}{2}$	173736.0	
				357.8
		$1\frac{1}{2}$	174093.8	
				520.1
		$2\frac{1}{2}$	174613.9	
$({}^3P)\,3d$	${}^4P$	$2\frac{1}{2}$	179495.2	
				−168.3
		$1\frac{1}{2}$	179663.5	
				−118.1
		$\frac{1}{2}$	179781.6	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^2\,(^3P)\,4p$	$^4D^\circ$	$\frac{1}{2}$	*201073.4*	
		$1\frac{1}{2}$	*201332.0*	258.6
		$2\frac{1}{2}$	*201765.1*	433.1
		$3\frac{1}{2}$	*202367.6*	602.5
$(^3P)\,4p$	$^4P^\circ$	$\frac{1}{2}$	*204021.6*	
		$1\frac{1}{2}$	*204124.0*	102.4
		$2\frac{1}{2}$	*204541.2*	417.2
$(^3P)\,4p$	$^4S^\circ$	$1\frac{1}{2}$	*205938.5*	
$(^3P)\,4d$	^4F	$1\frac{1}{2}$	239219.6	
		$2\frac{1}{2}$	239443.7	224.1
		$3\frac{1}{2}$	239788.6	344.9
		$4\frac{1}{2}$	240281.0	492.4
$(^3P)\,4d$	^4D	$\frac{1}{2}$	—	
		$1\frac{1}{2}$	241572.4	
		$2\frac{1}{2}$	241685.1	112.7
		$3\frac{1}{2}$	242046.2	361.1
$(^3P)\,5s$	^4P	$\frac{1}{2}$	244951.5	
		$2\frac{1}{2}$	245392.4	440.9
		$3\frac{1}{2}$	246137.2	744.8

$3s^2\,3p^3$	$^2D^\circ$	$1\frac{1}{2}$	*0*	
		$2\frac{1}{2}$	*59*	59
$3s^2\,3p^3$	$^2P^\circ$	$\frac{1}{2}$	11760	
		$1\frac{1}{2}$	11852	112
$3s^2\,3p^2\,(^3P)\,4s$	^2P	$\frac{1}{2}$	160316	
		$1\frac{1}{2}$	161022	706
—	1	$\frac{1}{2}$	162900	^2P ? 53
	2	$1\frac{1}{2}$	162953	^2P ?
$3s^2\,3p^2\,(^1D)\,4s$	^2D	$\frac{1}{2}$, $1\frac{1}{2}$	170394	
$3s^2\,3p^2\,(^3P)\,4p$	$^2D^\circ$	$1\frac{1}{2}$	*186983*	
		$2\frac{1}{2}$	—	
$3s^2\,3p^2\,(^3P)\,4p$	$^2P^\circ$	$\frac{1}{2}$	*190988*	
		$1\frac{1}{2}$	*191129*	141

Cl IV $\quad Z = 17$

14 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2\ {}^3P_0$

The classification of Cl IV has been given by Bowen in a study of a group of isoelectronic spectra. The classification is based entirely on observations in the far ultra-violet.

Reference

I. S. Bowen, *Phys. Rev.* **31**, 34 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p^2$	^3P	0	0.0	
				491.0
		1	491.0	
				850.0
		2	1341.0	
$3s\ 3p^3$	$^3D^\circ$	1	*102752.0*	
				35.6
		2	*102787.6*	
				81.4
		3	*102869.0*	
$3s\ 3p^3$	$^3P^\circ$	1	*120274.4*	
		2	*120256.3*	
		0	*120300.0*	
$3s\ 3p^3$	$^3S^\circ$	1	*164721.0*	
$3s^2\ 3p\ 3d$	$^3D^\circ$	1, 2, 3	*166742.0*	
$3s^2\ 3p\ 3d$	$^3P^\circ$	0, 1, 2	*182076.0*	
$3s^2\ 3p\ 4s$	$^3P^\circ$	0	*215023.0*	
				360.0
		1	*215383.0*	
				1081.0
		2	*216464.0*	

Cl V $\qquad Z = 17$

13 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p\ ^2P_{\frac{1}{2}}^{\circ}$

The classification of Cl V has been given most completely by Bowen.

No intercombinations have been observed so the quartets and doublets are given in separate tables.

Reference

I. S. Bowen, *Phys. Rev.* **31**, 34 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*0* *1492*	1492
$3s\ 3p^2$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	113234 113306	72
$3s\ 3p^2$	^2S	$\frac{1}{2}$	146644	
$3s\ 3p^2$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	157931 158892	961
$3s^2\ 3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	185861 185893	32
$3s^2\ 4s$	^2S	$\frac{1}{2}$	256352	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\,3p^2$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	0.0 537.7 1381.2	537.7 843.5
$3p^3$	$^4S^\circ$	$1\frac{1}{2}$	*147757.4*	

Cl VI

$Z = 17$

12 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ ^1S_0$

These terms of Cl VI are given on the basis of a $PP°$ group found by Bowen and Millikan in the far ultra-violet. The central line of the group has not been separated, so that the large differences must be given alike although the small differences are not the same.

Bowen and Millikan have also found a line at $\nu = 148949.2$ which they classify as $3p^2\ ^1S_0$–$3s\ 3p\ ^1P_1°$.

Reference

I. S. Bowen and R. A. Millikan, *Phys. Rev.* **25**, 597 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\ 3p$	$^3P°$	0	*0*	
				522
		1	*522*	
				1180
		2	*1702*	
$3p^2$	^3P	0	136788	
				1668
		1	137456	
				1180
		2	138636	

Configuration	Symbol	J	Term value
$3s^2$	^1S	0	0
$3s\ 3p$	$^1P°$	1	*148949*

Cl VII $Z = 17$

11 electrons $1s^2\,2s^2\,2p^6\,3s\;{}^2S_{\frac{1}{2}}$

Bowen and Millikan have found two lines in Cl VII whose position they predicted by the irregular doublet law and whose separation they predicted from the regular doublet law.

Reference

I. S. Bowen and R. A. Millikan, *Phys. Rev.* **25**, 295 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^6\,3s$	${}^2S$	$\frac{1}{2}$	0.0	
$3p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*123001.2* *124890.7*	1889.5

Co I $Z = 27$

27 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2\ {}^4F_{4\frac{1}{2}}$

First ionization potential about 8.5 volts

The most complete classification of Co I has been given by Catalán. The assignment of electron configurations has been taken from Russell. Even multiplets of the same sort have been lettered *a*, *b*, *c* . . . ; odd ones *z*, *y*, *x* . . . The absolute value of the lowest state is probably about 69000 cm.$^{-1}$ with respect to $3d^8\ {}^3F$ of Co II.

References

M. A. Catalán, *Zeits. f. Physik* **47,** 89 (1928). Complete term table, additional classified lines, and intensity schemes. Complete references.

H. N. Russell, *Astrophys. Journ.* **66,** 184 (1927). Assignment of electron configurations.

W. F. Meggers and F. M. Walters, Jr., *Bur. Stand. Sci. Papers* **22,** 205 (1927).

L. S. Ornstein and J. Bouma, *Phys. Rev.* **36,** 679 (1930). Intensity measurements.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^7\ 4s^2$	$a\ {}^4F$	$4\frac{1}{2}$	0	
				−815.98
		$3\frac{1}{2}$	815.98	
				−590.85
		$2\frac{1}{2}$	1406.83	
				−402.47
		$1\frac{1}{2}$	1809.30	
$3d^8\ ({}^3F)\ 4s$	$b\ {}^4F$	$4\frac{1}{2}$	3482.76	
				−659.85
		$3\frac{1}{2}$	4142.61	
				−547.49
		$2\frac{1}{2}$	4690.10	
				−385.65
		$1\frac{1}{2}$	5075.75	
$3d^8\ ({}^3F)\ 4s$	$a\ {}^2F$	$3\frac{1}{2}$	7442.39	
				−1018.38
		$2\frac{1}{2}$	8460.77	
$3d^8\ ({}^3P)\ 4s$	$a\ {}^4P$	$2\frac{1}{2}$	13795.44	
				−240.76
		$1\frac{1}{2}$	14036.20	
				−362.95
		$\frac{1}{2}$	14399.15	
$3d^7\ 4s^2$	$b\ {}^4P$	$2\frac{1}{2}$	15183.98	
				−589.96
		$1\frac{1}{2}$	15773.94	
				−421.60
		$\frac{1}{2}$	16195.54	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^7\ 4s^2$	$a\ ^2G$	$4\frac{1}{2}$	16467.80	−765.80
		$3\frac{1}{2}$	17233.60	
$3d^7\ 4s^2$?	$a\ ^2D$	$1\frac{1}{2}$	16470.60	307.52
		$2\frac{1}{2}$	16778.12	
$3d^8\ (^3P)\ 4s$	$a\ ^2P$	$1\frac{1}{2}$	18389.51	−385.48
		$\frac{1}{2}$	18774.99	
$3d^7\ 4s^2$	$b\ ^2P$	$1\frac{1}{2}$	20500.70	−715.16
		$\frac{1}{2}$	21215.86	
$3d^9$	$b\ ^2D$	$2\frac{1}{2}$	21920.06	−1232.45
		$1\frac{1}{2}$	23152.51	
$3d^7\ 4s\ (^5F)\ 4p$	$z\ ^6F^\circ$	$5\frac{1}{2}$	*23611.72*	−243.89
		$4\frac{1}{2}$	*23855.61*	−470.44
		$3\frac{1}{2}$	*24326.05*	−407.18
		$2\frac{1}{2}$	*24733.23*	−307.88
		$1\frac{1}{2}$	*25041.11*	−191.61
		$\frac{1}{2}$	*25232.72*	
$3d^7\ 4s\ (^5F)\ 4p$	$z\ ^6D^\circ$	$4\frac{1}{2}$	*24627.78*	−641.55
		$3\frac{1}{2}$	*25269.33*	−470.50
		$2\frac{1}{2}$	*25739.83*	−323.30
		$1\frac{1}{2}$	*26063.13*	−187.20
		$\frac{1}{2}$	*26250.33*	
$3d^7\ 4s\ (^5F)\ 4p$	$z\ ^6G^\circ$	$6\frac{1}{2}$	*25137.95*	−430.74
		$5\frac{1}{2}$	*25568.69*	−368.83
		$4\frac{1}{2}$	*25937.52*	−294.44
		$3\frac{1}{2}$	*26231.95*	−217.94
		$2\frac{1}{2}$	*26449.90*	−147.65
		$1\frac{1}{2}$	*26597.55*	
$3d^7\ 4s\ (^5F)\ 4p$	$z\ ^4F^\circ$	$4\frac{1}{2}$	*28345.80*	−431.39
		$3\frac{1}{2}$	*28777.19*	−439.13
		$2\frac{1}{2}$	*29216.32*	−346.73
		$1\frac{1}{2}$	*29563.05*	
$3d^7\ 4s\ (^5F)\ 4p$	$z\ ^4G^\circ$	$5\frac{1}{2}$	*28845.16*	−424.52
		$4\frac{1}{2}$	*29269.68*	−465.41
		$3\frac{1}{2}$	*29735.09*	−367.81
		$2\frac{1}{2}$	*30102.88*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^7\,4s\,(^5F)\,4p$	$z\,^4D^\circ$	$3\frac{1}{2}$	29294.49	
				−654.25
		$2\frac{1}{2}$	29948.74	
				−494.82
		$1\frac{1}{2}$	30443.56	
				−298.99
		$\frac{1}{2}$	30742.55	
$3d^7\,4s\,(^3F)\,4p$	$z\,^2G^\circ$	$4\frac{1}{2}$	31699.61	
				−1033.38
		$3\frac{1}{2}$	32732.99	
$3d^7\,4s\,(^3F)\,4p$	$z\,^2F^\circ$	$3\frac{1}{2}$	31871.09	
				−754.15
		$2\frac{1}{2}$	32781.64	
$3d^8\,(^3F)\,4p$	$y\,^4D^\circ$	$3\frac{1}{2}$	32027.42	
				−627.03
		$2\frac{1}{2}$	32654.45	
				−496.15
		$1\frac{1}{2}$	33150.60	
				−298.44
		$\frac{1}{2}$	33449.04	
$3d^8\,(^3F)\,4p$	$y\,^4G^\circ$	$5\frac{1}{2}$	32430.56	
				−34.10
		$4\frac{1}{2}$	32464.66	
				−708.64
		$3\frac{1}{2}$	33173.30	
				−501.02
		$2\frac{1}{2}$	33674.32	
$3d^8\,(^3F)\,4p$	$y\,^4F^\circ$	$4\frac{1}{2}$	32841.91	
				−315.17
		$3\frac{1}{2}$	33466.78	
				−479.03
		$2\frac{1}{2}$	33945.81	
				−250.30
		$1\frac{1}{2}$	34196.11	
$3d^8\,(^3F)\,4p$	$y\,^2G^\circ$	$4\frac{1}{2}$	33439.64	
				−693.58
		$3\frac{1}{2}$	34133.50	
$3d^7\,4s\,(^3F)\,4p$	$z\,^2D^\circ$	$2\frac{1}{2}$	33462.80	
				−889.58
		$1\frac{1}{2}$	34352.38	
$3d^8\,(^3F)\,4p$	$y\,^2F^\circ$	$3\frac{1}{2}$	35450.51	
				−879.28
		$2\frac{1}{2}$	36329.79	
$3d^8\,(^3F)\,4p$	$y\,^2D^\circ$	$2\frac{1}{2}$	36092.40	
				−782.66
		$1\frac{1}{2}$	36875.06	
$3d^7\,4s\,(^3F)\,4p$	$x\,^4D^\circ$	$3\frac{1}{2}$	39649.04	
				−696.79
		$2\frac{1}{2}$	40345.83	
				−481.80
		$1\frac{1}{2}$	40827.63	
				−274.01
		$\frac{1}{2}$	41101.64	
—	1°	$2\frac{1}{2}$	40621.51	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^7\,4s\,(^3F)\,4p$	$x\,^4F^\circ$	$4\frac{1}{2}$	*41225.4*	
				−692.8
		$3\frac{1}{2}$	*41918.2*	
				−515.8
		$2\frac{1}{2}$	*42434.0*	
				−362.7
		$1\frac{1}{2}$	*42796.7*	
$3d^7\,4s\,(^3F)\,4p$	$x\,^4G^\circ$	$5\frac{1}{2}$	*41528.3*	
				−740.7
		$4\frac{1}{2}$	*42269.0*	
				−541.6
		$3\frac{1}{2}$	*42810.6*	
				−388.8
		$2\frac{1}{2}$	*43199.4*	
—	$z\,^4P^\circ$	$2\frac{1}{2}$	*41968.74*	
				−13.83
		$1\frac{1}{2}$	*41982.57*	
				12.79
		$\frac{1}{2}$	*41969.78*	
—	2°	$4\frac{1}{2}$	*42609.4*	
	3°	$\frac{1}{2}$	*43130.13*	
	4°	$2\frac{1}{2}$	*43242.89*	
	5°	$1\frac{1}{2}$	*43263.47*	
	6°	$4\frac{1}{2}$	*43294.9*	
	7°	$3\frac{1}{2}$	*43398.50*	
	8°	$2\frac{1}{2}$	*43425.63*	
	9°	$1\frac{1}{2}$	*43537.62*	
	10°	$3\frac{1}{2}$	*43555.10*	
	11°	$3\frac{1}{2}$	*43847.86*	
	12°	$1\frac{1}{2}$	*49311.36*	
	13°	$2\frac{1}{2}$	*43921.75*	
	14°	$2\frac{1}{2}$	*44162.1*	
	15°	$2\frac{1}{2}$	*44201.87*	
	16°	$\frac{1}{2}$	*44453.0*	
	17°	$2\frac{1}{2}$ or $1\frac{1}{2}$	*44555.6*	
$3d^8\,(^3F)\,4s$	$c\,^4F$	$4\frac{1}{2}$	44781.94	
				−323.45
		$3\frac{1}{2}$	45105.39	
				−770.98
		$2\frac{1}{2}$	45876.37	
				−498.63
		$1\frac{1}{2}$	46375.00	
$3d^7\,4s\,(^5F)\,5s$	$a\,^6F$	$5\frac{1}{2}$	45675.88	
				−547.00
		$4\frac{1}{2}$	46222.88	
				−483.82
		$3\frac{1}{2}$	46706.70	
				−383.78
		$2\frac{1}{2}$	47090.48	
				−274.06
		$1\frac{1}{2}$	47364.54	
				−163.78
		$\frac{1}{2}$	47528.32	
—	18°	$1\frac{1}{2}$	*45904.66*	

COBALT I

(Concluded)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8\,(^3F)\,4s$	$b\,^2F$	3½	45924.79	−821.00
		2½	46745.79	
—	19°	3½	*45971.09*	
	20°	2½	*46002.76*	
	21°	1½	*46186.33*	
	22°	1½	*46259.97*	
	23°	2½	*46329.60*	
	24°	1½	*46562.74*	
	25°	2½	*46671.89*	
	26°	1½	*46685.36*	
—	$w\,^4D°$	3½	*46872.53*	−519.32
		2½	*47393.85*	−218.27
		1½	*47612.12*	−293.09
		½	*47905.21*	
$3d^7\,4s\,(^5F)\,5s$	$d\,^4F$	4½	47524.42	−677.14
		3½	48201.56	−516.90
		2½	48718.46	−359.87
		1½	49078.33	
—	27°	1½ or 2½	*47981.7*	
—	$v\,^4D°$	3½	*48217.32*	−226.35
		2½	*48443.67*	−102.28
		1½	*49545.95*	−25.69
		½	*48571.64*	
—	28	3½ or 2½	51042.19	
	29	3½	51053.02	
	30	6½	51142.57	
	31	4½	51170.14	
	32	5½	51174.26	
	33	3½	51199.82	
	34	2½ or 1½	51200.7	
	35	5½ or 4½	51203.80	
	36	4½ or 3½	51267.96	
	37	2½	51560.75	
	38	2½	52070.08	
	39	3½ or 2½	52094.98	
	40	3½ or 2½	52121.26	
	41	2½	52460.04	
	42	3½	52716.62	
	43	4½	52864.28	
	44	2½	52970.60	
	45	2½ or 1½	53343.29	

Co II $Z = 27$

26 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^8\;{}^3F_4$

Ionization potential = 17.3 volts to $3d^7\;{}^4F$ of Co III

These terms are from the work of Findlay who has studied the Zeeman effect, and considerably modified and extended the previous work of Meggers. The absolute value of the lowest state is estimated as 140000 cm.$^{-1}$ with respect to $3d^7\;{}^4F$ of Co III.

Reference

J. H. Findlay, *Phys. Rev.* **36**, 5 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8$	${}^3F$	4	0.0	
				−950.3
		3	950.3	
				−646.9
		2	1597.2	
$3d^7\,({}^4F)\,4s$	${}^5F$	5	3350.5	
				−678.4
		4	4028.9	
				−531.9
		3	4560.8	
				−389.2
		2	4950.0	
				−254.5
		1	5204.5	
$3d^7\,({}^4F)\,4s$	${}^3F$	4	9812.7	
				−895.4
		3	10708.1	
				−613.4
		2	11321.5	
$3d^7\,({}^4P)\,4s$	${}^5P$	3	17771.5	
				−260.0
		2	18031.5	
				−307.0
		1	18338.5	
$3d^7\,({}^4F)\,4p$	${}^5F^\circ$	5	*45197.8*	
				−181.0
		4	*45378.8*	
				−593.3
		3	*45972.1*	
				−480.5
		2	*46452.6*	
				−333.7
		1	*46786.3*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^7\,(^4F)\,4p$	$^5D^\circ$	4	*46320.8*	
				−718.2
		3	*47039.0*	
				−498.1
		2	*46537.1*	
				−311.4
		1	*47848.5*	
				−146.6
		0	*47995.1*	
$3d^7\,(^4F)\,4p$	$^5G^\circ$	6	*47078.2*	
				−267.5
		5	*47345.7*	
				−461.5
		4	*47807.2*	
				−343.5
		3	*48150.7*	
				−237.4
		2	*48388.1*	
$3d^7\,(^4F)\,4p$	$^3G^\circ$	5	*48555.9*	
				−792.3
		4	*49348.2*	
				−687.7
		3	*50035.9*	
$3d^7\,(^4F)\,4p$	$^3F^\circ$	4	*49697.5*	
				−684.1
		3	*50381.6*	
				−532.2
		2	*50913.8*	
$3d^7\,(^4F)\,4p$	$^3D^\circ$	3	*51512.2*	
				−717.4
		2	*52229.6*	
				−454.9
		1	*52684.5*	
$3d^7\,(^4P)\,4p$	$^5S^\circ$	2	*56010.6*	
$3d^7\,(^4P)\,4p$	$^5D^\circ$	3	*61240.8*	
		2	*61260.1*	
		1	*61348.5 ?*	
		4	*61388.1*	
		0	*61457.9*	
$3d^7\,(^4P)\,4p$	$^5P^\circ$	3	*63344.1*	
				−22.8
		2	*63366.9*	
				−298.1
		1	*63665.0*	
$3d^7\,(^4P)\,4p$	$^3P^\circ$	2	*63615.7*	
$3d^7\,(^4F)\,5s$	^5F	5	84012.3	
				−572.5
		4	84584.8	
				−580.5
		3	85165.3	
				−482.6
		2	85593.9	
				−280.2
		1	85874.1	
$3d^7\,(^4F)\,5s$	^3F	4	85479.2	
				−864.6
		3	86343.8	
				−593.9
		2	86937.7	

Cr I $Z = 24$

24 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s\ ^7S_3$

First ionization potential = 6.74 volts

The term values of Cr I are from the tables of Kiess. Even multiplets of the same kind are lettered *a*, *b*, *c*, . . . in order of occurrence; odd ones, *z*, *y*, *x*, . . .

The absolute value of the lowest term is given by Gieseler to be 54541 cm.$^{-1}$ with respect to the $3d^5\ ^6S$ of Cr II.

References

H. Gieseler, *Zeits. f. Physik* **22**, 228 (1924). Partial classification, Zeeman effect, other references.

C. C. Kiess, *Bur. Stand. Journ. Res.* **5**, 775 (1930). Term values.

Configuration	Symbol	J	Term value	$\Delta\nu$	
$3d^5\ (^6S)\ 4s$	$a\ ^7S$	3	0		
$3d^5\ (^6S)\ 4s$	$a\ ^5S$	2	7593.1		
$3d^4\ 4s^2$	$a\ ^5D$	0	7750.7		
				60.0	
		1	7810.7		
				116.7	
		2	7927.4		
				167.8	
		3	8095.2		
				212.3	
		4	8307.5		
$3d^5\ (^4G)\ 4s$	$a\ ^5G$	2	20517.5		
				3.5	
		3	20521.0		
				2.6	
		4	20523.6		
				0.2	
		5	20523.8		
				−4.5	
		6	20519.3		
—	$a\ ^5P$	3	21840.7		$3d^5\ (^4D)\ 4s\ ^3D$?
				−7.2	
		2	21847.9		
				−9.1	
		1	21857.0		
$3d^5\ (^6S)\ 4p$	$z\ ^7P^\circ$	2	*23305.0*		
				81.4	
		3	*23386.4*		
				112.5	
		4	*23498.9*		

CHROMIUM I

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5\ (^4D)\ 4s$	$b\ ^5D$	0	24277.1	
		1	24286.6	9.5
		2	24299.8	13.2
		3	24303.9	4.1
		4	24282.3	−21.6
$3d^4\ 4s\ (^6D)\ 4p$	$z\ ^7F^\circ$	0	*24971.1*	
		1	*25010.7*	39.6
		2	*25089.2*	78.5
		3	*25206.0*	116.8
		4	*25359.6*	153.6
		5	*25548.6*	189.0
		6	*24771.5*	222.9
$3d^5\ (^6S)\ 4p$	$z\ ^5P^\circ$	3	*26787.3*	
		2	*26796.1*	−8.8
		1	*26801.8*	−5.7
$3d^4\ 4s\ (^6D)\ 4p$	$z\ ^7D^\circ$	1	*27300.3*	
		2	*27382.1*	81.8
		3	*27500.3*	118.2
		4	*27649.7*	149.4
		5	*27825.2*	175.5
$3d^4\ 4s\ (^6D)\ 4p$	$y\ ^7P^\circ$	2	*27728.9*	
		3	*27820.3*	91.4
		4	*27935.3*	115.0
$3d^4\ 4s\ (^6D)\ 4p$	$y\ ^5P^\circ$	1	*29420.7*	
		2	*29584.5*	163.8
		3	*29824.7*	240.2
$3d^4\ 4s\ (^6D)\ 4p$	$z\ ^5F^\circ$	1	*30787.1*	
		2	*30858.5*	71.4
		3	*30965.2*	106.7
		4	*31106.2*	141.0
		5	*31280.0*	173.8
$3d^4\ 4s\ (^6D)\ 4p$	$z\ ^5D^\circ$	0	*33337.6*	
		1	*33423.6*	86.0
		2	*33542.0*	118.4
		3	*33671.4*	129.4
		4	*33816.0*	144.6
$3d^4\ 4s\ (^4D)\ 4p$	$z\ ^3P^\circ$	0	*33762.6*	
		1	*33897.3*	134.7
		2	*34190.7*	293.4

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5\ (^6S)\ 5s$	$b\ ^7S$	3	36895.8	
$3d^5\ (^6S)\ 5s$	$b\ ^5S$	2	37883.1	
$3d^4\ 4s\ (^4D)\ 4p$	$z\ ^3D^\circ$	1	*38597.1*	
		2	*38730.7*	133.6
		3	*38911.4*	180.7
$3d^4\ 4s\ (^4D)\ 4p$	$y\ ^5F^\circ$	1	*40906.5*	
		2	*40971.6*	65.1
		3	*41086.3*	114.7
		4	*41224.8*	138.5
		5	*41393.4*	168.6
$3d^4\ 4s\ (^4D)\ 4p$	$x\ ^5P^\circ$	1	*40930.2*	
		2	*40982.7*	52.5
		3	*41043.4*	60.7
$3d^4\ 4s\ (^4D)\ 4p$	$y\ ^5D^\circ$	0	*41124.7*	
		1	*41289.2*	164.5
		2	*41408.9*	119.7
		3	*41575.2*	166.3
		4	*41782.2*	207.0
—	$x\ ^5D^\circ$	0	*42218.3*	
		1	*42292.8*	74.5
		2	*42438.8*	146.0
		3	*42648.4*	209.6
		4	*42908.4*	260.0
—	$x\ ^7P^\circ$	2	*42237.0*	
		3	*42251.9*	14.9
		4	*42277.0*	25.1
$3d^5\ (^6S)\ 4d$	$a\ ^7D$	1	42253.3	
		2	42254.5	1.2
		3	42256.2	1.7
		4	42258.4	2.2
		5	42261.3	2.9
—	$z\ ^5G^\circ$	2	*42515.4*	
		3	*42538.8*	23.4
		4	*42564.8*	26.0
		5	*42589.0*	24.2
		6	*42605.5*	16.5

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$w\ ^5P^\circ$	1	*44125.9*	
				61.1
		2	*44187.0*	
				72.5
		3	*44259.5*	
	$y\ ^5G^\circ$	2	*44299.9*	
				73.4
		3	*44373.3*	
				161.1
		4	*44534.4*	
				56.7
		5	*44591.1*	
				154.8
		6	*44745.9*	
	$v\ ^5P^\circ$	1	*44666.7*	
				208.3
		2	*44875.0*	
				238.1
		3	*45113.1*	
	$x\ ^5F^\circ$	1	*45201.5*	
				23.4
		2	*45224.9*	
				30.4
		3	*45255.3*	
				30.5
		4	*45285.8*	
				20.0
		5	*45305.8*	
	$z\ ^5H^\circ$	3	*45565.9*	
				48.9
		4	*45614.8*	
				48.3
		5	*45663.1*	
				44.0
		6	*45707.1*	
				34.1
		7	*45741.2*	
$3d^5\ (^6S)\ 6s$	$c\ ^5S^\circ$	2	*45967.7*	
—	$y\ ^3D^\circ$	1	*46077.1*	
				31.9
		2	*46109.0*	
				65.2
		3	*46174.2*	
	$w\ ^5D^\circ$	0	—	
		1	—	
		2	*46349.5*	
				18.9
		3	*46368.4*	
				53.8
		4	*46422.2*	
$3d^4\ 4s\ (^6D)\ 5s$	$b\ ^7D$	1	46448.6	
				76.3
		2	46524.9	
				112.3
		3	46637.2	
				145.7
		4	46782.9	
				176.2
		5	46959.1	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$w\ ^5F^\circ$	1	*46678.4*	−1.1
		2	*46677.3*	10.8
		3	*46688.1*	32.1
		4	*46720.2*	−15.3
		5	*46704.9*	
	$u\ ^5P^\circ$	3	*46878.5*	−89.1
		2	*46967.6*	−54.3
		1	*47021.9*	
	$x\ ^5G^\circ$	2	*47047.6*	78.2
		3	*47125.8*	64.2
		4	*47190.0*	38.6
		5	*47228.6*	−6.5
		6	*47222.1*	
	$v\ ^5F^\circ$	1	*47629.1*	1.8
		2	*47630.9*	4.6
		3	*47635.5*	3.6
		4	*47639.1*	4.9
		5	*47644.0*	
	$u\ ^5F^\circ$	1	*47877.4*	40.4
		2	*47917.8*	56.6
		3	*47974.4*	39.9
		4	*48014.3*	−28.8
		5	*47985.5*	
	$c\ ^7D$	1	47699.2	1.4
		2	47700.6	1.8
		3	47702.4	2.9
		4	47705.3	4.5
		5	47709.8	
	$^5D^\circ$	0	*47788.1*	−15.7
		1	*47772.4*	13.7
		2	*47786.1*	28.2
		3	*47814.3*	52.1
		4	*47866.4*	
$3d^4\ 4s\ (^6D)\ 5s$	$c\ ^5D$	0	—	
		1	—	
		2	48558.5	102.9
		3	48661.4	162.9
		4	48824.3	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$w\ ^5G^\circ$	2	49466.8	53.0
		3	49519.8	53.2
		4	49573.0	44.4
		5	49617.4	17.6
		6	49635.0	
	$t\ ^5P^\circ$	1	49588.8	9.2
		2	49598.0	
		3	—	
	$s\ ^5P^\circ$	3	49812.3	−10.2
		2	49822.5	
		1	—	
	$t\ ^5F^\circ$	1	50018.9	38.6
		2	50057.5	44.6
		3	50102.3	108.6
		4	50210.8	42.3
		5	50253.1	
	$u\ ^5D^\circ$	4	50557.5	−70.6
		3	50628.1	−26.6
		2	50654.7	−8.2
		1	50662.9	1.7
		0	50661.2	
	$t\ ^5D^\circ$	0	52000.5	3.2
		1	52003.7	9.1
		2	52012.8	19.1
		3	52031.9	32.7
		4	52064.6	
	$s\ ^5F^\circ$	1	53011.6	25.2
		2	53036.8	32.9
		3	53069.7	47.6
		4	53117.3	54.8
		5	53172.1	
	$r\ ^5F^\circ$	1	54199.9	54.0
		2	54253.9	76.1
		3	54330.0	96.7
		4	54426.7	111.2
		5	54537.9	

Cr II $\qquad Z = 24$

23 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^5\; {}^6S_{2\frac{1}{2}}$

First ionization potential = 16.6 volts

The term values of Cr II are from the tables of Kiess. Even multiplets of the same kind are lettered *a*, *b*, *c*, . . . in order of occurrence; odd ones, *z*, *y*, *x*, . . .

The absolute value of the lowest state is estimated by Russell to be about 135000 cm.$^{-1}$

References

H. N. Russell, *Astrophys. Journ.* **66**, 184 (1927). Assignment of electron configurations. Ionization potential.

E. Krömer, *Zeits. f. Physik* **52**, 531 (1928). Zeeman effect.

C. C. Kiess, *Bur. Stand. Journ. Res.* **5**, 775 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5$	$a\,{}^6S$	$2\frac{1}{2}$	0	
$3d^4\,({}^5D)\,4s$	$a\,{}^6D$	$\frac{1}{2}$	11963.5	
		$1\frac{1}{2}$	12034.3	70.8
		$2\frac{1}{2}$	12149.7	115.4
		$3\frac{1}{2}$	12305.7	156.0
		$4\frac{1}{2}$	12498.3	192.6
—	$a\,{}^2P$	$\frac{1}{2}$	16896.6	
		$1\frac{1}{2}$	17593.3	696.7
$3d^4\,({}^5D)\,4s$	$a\,{}^4D$	$\frac{1}{2}$	19529.9	
		$1\frac{1}{2}$	19632.9	130.3
		$2\frac{1}{2}$	19799.5	166.6
		$3\frac{1}{2}$	20025.5	226.0
$3d^5$	$a\,{}^4G$	$2\frac{1}{2}$	20514.2	
		$3\frac{1}{2}$	20519.7	5.5
		$4\frac{1}{2}$	20521.1	1.4
		$5\frac{1}{2}$	20514.2	−6.9
$3d^5$?	$a\,{}^2D$	$2\frac{1}{2}$	21824.4	
		$1\frac{1}{2}$	21826.0	−1.6

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5$	$b\ ^4D$	$3\frac{1}{2}$	25035.4	
				−13.0
		$2\frac{1}{2}$	25048.4	
				−3.9
		$1\frac{1}{2}$	25044.5	
				−7.2
		$\frac{1}{2}$	25037.3	
—	$a\ ^4P$	$\frac{1}{2}$	29953.8	
				355.3
		$1\frac{1}{2}$	30309.1	
				557.0
		$2\frac{1}{2}$	30866.1	
$3d^4\ (^3H)\ 4s$	$a\ ^4H$	$3\frac{1}{2}$	30159.5	
				61.6
		$4\frac{1}{2}$	30221.1	
				79.2
		$5\frac{1}{2}$	30300.3	
				93.1
		$6\frac{1}{2}$	30393.4	
$3d^4\ (^3F)\ 4s$	$a\ ^4F$	$1\frac{1}{2}$	31084.6	
				35.4
		$2\frac{1}{2}$	31119.1	
				51.2
		$3\frac{1}{2}$	31170.3	
				50.8
		$4\frac{1}{2}$	31221.1	
$3d^5$	$b\ ^4F$	$1\frac{1}{2}$	32846.5	
				10.2
		$2\frac{1}{2}$	32856.7	
				−18.2
		$3\frac{1}{2}$	32838.5	
				17.3
		$4\frac{1}{2}$	32855.8	
$3d^4\ (^3G)\ 4s$	$b\ ^4G$	$2\frac{1}{2}$	33419.6	
				103.1
		$3\frac{1}{2}$	33522.7	
				97.7
		$4\frac{1}{2}$	33620.4	
				75.3
		$5\frac{1}{2}$	33695.7	
$3d^4\ (^5D)\ 4p$	$z\ ^6F^\circ$	$\frac{1}{2}$	*46825.2*	
				81.7
		$1\frac{1}{2}$	*46906.9*	
				135.2
		$2\frac{1}{2}$	*47042.1*	
				186.9
		$3\frac{1}{2}$	*47229.0*	
				237.5
		$4\frac{1}{2}$	*47466.5*	
				286.9
		$5\frac{1}{2}$	*47753.4*	
—	$z\ ^2S^\circ$	$\frac{1}{2}$	*47266.7*	
$3d^4\ (^5D)\ 4p$	$z\ ^6P^\circ$	$1\frac{1}{2}$	*48400.8*	
				92.2
		$2\frac{1}{2}$	*48493.0*	
				140.9
		$3\frac{1}{2}$	*48633.9*	
—	$z\ ^4P^\circ$	$\frac{1}{2}$	*48750.9*	
				256.7
		$1\frac{1}{2}$	*49007.6*	
				345.7
		$2\frac{1}{2}$	*49353.3*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$z\ ^2P^\circ$	$\frac{1}{2}$	*49109.2*	198.7
		$1\frac{1}{2}$	*49307.9*	
$3d^4\ (^5D)\ 4p$	$z\ ^6D^\circ$	$\frac{1}{2}$	—	
		$1\frac{1}{2}$	—	
		$2\frac{1}{2}$	*49491.8*	155.7
		$3\frac{1}{2}$	*49647.5*	192.6
		$4\frac{1}{2}$	*49840.1*	
$3d^4\ (^5D)\ 4p$	$y\ ^4P^\circ$	$\frac{1}{2}$	*49494.4*	71.8
		$1\frac{1}{2}$	*49566.2*	141.7
		$2\frac{1}{2}$	*49707.9*	
$3d^4\ (^5D)\ 4p$	$z\ ^4F^\circ$	$1\frac{1}{2}$	*51586.0*	85.1
		$2\frac{1}{2}$	*51671.1*	119.4
		$3\frac{1}{2}$	*51790.5*	154.0
		$4\frac{1}{2}$	*51944.5*	
$3d^4\ (^3D)\ 4p$	$z\ ^4D^\circ$	$3\frac{1}{2}$	*54419.6*	−81.6
		$2\frac{1}{2}$	*54501.2*	−126.1
		$1\frac{1}{2}$	*54627.3*	−158.8
		$\frac{1}{2}$	*54786.1*	
—	$y\ ^2P^\circ$	$\frac{1}{2}$	*57970.3*	3.7
		$1\frac{1}{2}$	*57974.0*	
$3d^4\ (^3H)\ 4p$	$z\ ^4H^\circ$	$3\frac{1}{2}$	*63603.4*	104.8
		$4\frac{1}{2}$	*63708.2*	142.2
		$5\frac{1}{2}$	*63850.4*	181.7
		$6\frac{1}{2}$	*64032.1*	
—	$y\ ^4D^\circ$	$\frac{1}{2}$	*63803.3*	260.1
		$1\frac{1}{2}$	*64063.4*	386.9
		$2\frac{1}{2}$	*64450.3*	475.9
		$3\frac{1}{2}$	*64926.2*	
$3d^4\ 4p$?	$z\ ^4G^\circ$	$2\frac{1}{2}$	*65158.0*	100.5
		$3\frac{1}{2}$	*65258.5*	127.1
		$4\frac{1}{2}$	*65385.6*	
		$5\frac{1}{2}$	—	
$3d^4\ (^3G)\ 4p$	$y\ ^4H^\circ$	$3\frac{1}{2}$	*68845.3*	148.3
		$4\frac{1}{2}$	*68993.6*	177.9
		$5\frac{1}{2}$	*69171.5*	218.0
		$6\frac{1}{2}$	*69389.5*	

Cr III $Z = 24$

22 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^4\ {}^5D_0$

The classification is given by White. No intercombinations between triplets and quintets have been found. The lowest state has not yet been located. The absolute value of the $3d^4\ {}^3F$ has been estimated to be 222000 cm.$^{-1}$ and of the $3d^3\, 4s\ {}^5F$ to be 192000 cm.$^{-1}$ both with respect to $3d^3\ {}^4F$ of Cr IV.

Reference

H. E. White, *Phys. Rev.* **33,** 914 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^4$	^3F	2	0	
				56
		3	56	
				75
		4	131	
$3d^4$	^3G	3	2250	
				148
		4	2398	
				146
		5	2544	
$3d^3\ (^4F)\ 4s$	^3F	2	38194	
				342
		3	38536	
				430
		4	38966	
$3d^3\ (^4F)\ 4p$	$^3D^\circ$	1	*78621*	
				228
		2	*78849*	
				378
		3	*79227*	
$3d^3\ (^4F)\ 4p$	$^3G^\circ$	3	*81384*	
				259
		4	*81643*	
				323
		5	*81966*	
$3d^3\ (^4F)\ 4p$	$^3F^\circ$	2	*82988*	
				302
		3	*83290*	
				354
		4	*83644*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\ (^4F)\ 4s$	^5F	1	0	
		2	136	136
		3	336	200
		4	559	263
		5	918	319
$3d^3\ (^4F)\ 4p$	$^5G°$	2	*44273*	
		3	*44537*	264
		4	*44884*	347
		5	*45309*	425
		6	*45813*	504
$3d^3\ (^4F)\ 4p$	$^5F°$	1	*47281*	
		2	*47428*	147
		3	*47628*	200
		4	*47867*	239
		5	*48126*	259
$3d^3\ (^4F)\ 4d$	^5H	3	102694	
		4	102878	184
		5	103107	229
		6	103387	280
		7	103710	323

Cr IV $Z = 24$

21 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^3\;{}^4F_{1\frac{1}{2}}$

The classification is taken from White. Intercombinations between quartets and doublets are very weak, and their relative position therefore not quite certain.

Reference

H. E. White, *Phys. Rev.* **33**, 676 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3$	^4F	$1\frac{1}{2}$	0	
		$2\frac{1}{2}$	233	233
		$3\frac{1}{2}$	558	325
		$4\frac{1}{2}$	949	391
	^2G	$3\frac{1}{2}$	15014	
		$4\frac{1}{2}$	15371	357
	^2H	$4\frac{1}{2}$	21027	
		$5\frac{1}{2}$	21278	251
$3d^2\,(^3F)\,4s$	^4F	$1\frac{1}{2}$	103989	
		$2\frac{1}{2}$	104253	264
		$3\frac{1}{2}$	104625	372
		$4\frac{1}{2}$	105101	476
	^2F	$2\frac{1}{2}$	109903	
		$3\frac{1}{2}$	110663	760
$3d^2\,(^3F)\,4p$	$^4G^\circ$	$2\frac{1}{2}$	*157354*	
		$3\frac{1}{2}$	*157926*	572
		$4\frac{1}{2}$	*158622*	696
		$5\frac{1}{2}$	*159443*	821
	$^4F^\circ$	$1\frac{1}{2}$	*158519*	
		$2\frac{1}{2}$	*158885*	366
		$3\frac{1}{2}$	*159344*	459
		$4\frac{1}{2}$	*159856*	512

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3F)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	*160265*	
				642
		$3\frac{1}{2}$	*160907*	
	$^4D^\circ$	$\frac{1}{2}$?	*161513*	
				321
		$1\frac{1}{2}$?	*161834*	
				461
		$2\frac{1}{2}$	*162295*	
				−235
		$3\frac{1}{2}$	*162060*	
	$^2G^\circ$	$3\frac{1}{2}$	*164870*	
				527
		$4\frac{1}{2}$	*165397*	
$3d^2\ (^3F)\ 4d$	^4H	$3\frac{1}{2}$	233350	
				350
		$4\frac{1}{2}$	233700	
				389
		$5\frac{1}{2}$	234089	
				400
		$6\frac{1}{2}$	234489	

Cr V $\quad Z = 24$

20 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^2\;{}^3F_2$

Ionization potential = 73 volts

The classification has been given by White. The absolute value of the lowest state has been estimated to be 589000 cm.$^{-1}$ with respect to $3d\;{}^2D$ of Cr VI.

Reference

H. E. White, *Phys. Rev.* **33**, 543 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2$	^3F	2	0	
				500
		3	500	
				637
		4	1137	
	^1D	2	14921	
	^3P	0	15470	
				208
		1	15678	
				368
		2	16046	
	^1G	4	23237	
	^1S	0	25295	
$3d\,4s$	^3D	1	167159	
				314
		2	167473	
				598
		3	168071	
	^1D	2	172908	
$3d\,4p$	$^1D^\circ$	2	*227845*	
	$^3D^\circ$	1	*227987*	
				487
		2	*228474*	
				631
		3	*229105*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\,4p$	$^3F^\circ$	2	*229537*	
				762
		3	*230299*	
				1076
		4	*231375*	
	$^3P^\circ$	1	*234596*	
		0	*234651*	
		2	*234826*	
	$^1F^\circ$	3	*238740*	
	$^1P^\circ$	1	*241624*	
$3d\,4d$	^3G	3	319295	
				485
		4	319780	
				593
		5	320373	

Cr VI $\qquad Z = 24$

19 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d\ ^2D_{1\frac{1}{2}}$

The classification has been given by Gibbs and White.

Reference

R. C. GIBBS and H. E. WHITE, *Phys. Rev.* **33**, 157 (1929); *Proc. Nat. Acad. Sci.* **12**, 676 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d$	^2D	$1\frac{1}{2}$	0	957
		$2\frac{1}{2}$	957	
$4s$	^2S	$\frac{1}{2}$	227776	
$4p$	$^2P^\circ$	$\frac{1}{2}$	*296489*	1822
		$1\frac{1}{2}$	*298311*	

Cs I $\qquad\qquad Z = 55$

55 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s^2\,5p^6\,6s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 3.87 volts

The classification of Cs I has been taken from Fowler and from Paschen-Götze. It is of interest to note that the F terms are inverted as far as they have been separated. The lowest F term has not been separated because its combination with the $5d\ {}^2D$ lies in the infra-red.

The normal state ${}^2S_{\frac{1}{2}}$ has been found to have a hyperfine structure with separation 0.30 cm.$^{-1}$. All term values are given with respect to the $5p^6\ {}^1S_0$ of Cs II.

References

D. A. Jackson, *Proc. Roy. Soc.* **A121,** 432 (1928). Hyperfine structure.
I. M. Matthews, *Proc. Roy. Soc.* **A120,** 650 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s$	${}^2S$	$\frac{1}{2}$	31404.6	
$6p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*20226.3* *19672.3*	554.0
$5d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	16905.0 16807.1	97.59
$7s$	${}^2S$	$\frac{1}{2}$	12868.9	
$7p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*9639.2* *9458.1*	181.1
$6d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	8815.6 8772.8	42.8
$8s$	${}^2S$	$\frac{1}{2}$	7087.8	
$4f$	${}^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*6932.8*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$8p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*5695.3* *5614.7*	80.6
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	5356.5 5335.6	20.9
$9s$	^2S	$\frac{1}{2}$	4494.9	
$5f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*4433.08* *4432.92*	−0.16

SERIES

ms	
m	$^2S_{\frac{1}{2}}$
6	31404.6
7	12868.9
8	7087.8
9	4494.9
10	3105.5
11	2274.0
12	1738.0

SERIES (*Concluded*)

mp		
m	$^2P_{\frac{1}{2}}°$	$^2P_{1\frac{1}{2}}°$
6	*20266.3*	*19672.3*
7	*9639.2*	*9458.1*
8	*5695.3*	*5614.7*
9	*3768.4*	*3723.3*
10	*2678.2*	*2651.4*
11	*2002.2*	*1985.1*
12	*1551.0*	*1539.6*
13	*1238.6*	*1230.6*
14	*1010.1*	*1004.8*

(15)	*836.0*	(26)	*217.5*
(16)	*707.1*	(27)	*199.6*
(17)	*605.4*	(28)	*183.3*
(18)	*525.1*	(29)	*169.4*
(19)	*459.3*	(30)	*157.1*
(20)	*405.8*	(31)	*145.4*
(21)	*359.9*	(32)	*135.9*
(22)	*322.3*	(33)	*125.4*
(23)	*289.1*	(34)	*117.7*
(24)	*261.6*	(35)	*109.6*
(25)	*238.3*	(36)	*103.2*

md		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
5	16905.0	16807.41
6	8815.6	8772.8
7	5356.5	5335.6
8	3592.7	3581.1
9	2575.7	2567.5
10	1936.1	1931.7
11	1508.3	1505.0
12	1208.6	1207.5
13	996.4	988.7
14	828.5	823.1

mf		
m	$^2F_{2\frac{1}{2}}°$	$^2F_{3\frac{1}{2}}°$
4	*6932.80*	*6932.80*
5	*4432.92*	*4433.08*
6	*3074.72*	*3074.83*
7	*2256.26*	*2256.33*
8	*1725.52*	*1725.52*
9	*1361.96*	*1361.96*
10	*1102.09*	*1102.09*
11	*909.89*	*909.89*

mg	
m	$^2G_{3\frac{1}{2},\,4\frac{1}{2}}$
5	4393.5
6	3057.0

mh	
m	$^2H°$
6	*3046.1*

Cs II $Z = 55$

54 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ {}^1S_0$

Ionization potential about 23.4 volts

This classification has been given by Miller and Laporte. The p^5d and p^5s levels overlap and cannot be distinguished with certainty. The probable identification of the p^5s levels, given by Miller and Laporte, is indicated in the last column. The absolute value of the lowest state is given as 189244 cm.$^{-1}$ with respect to the $5p^5\ {}^2P_{1\frac{1}{2}}$ of Cs III.

Reference

G. R. Miller and O. Laporte, unpublished material.

Configuration	Symbol	J	Term value	
$5p^6$	${}^1S_0$	0	0	
$5p^5\ ({}^2P_{1\frac{1}{2}})\ 5d$ and $6s$	$8°$	2	*107392.28*	$({}^2P_{1\frac{1}{2}})\ 6s\ {}^3P_2$
	$9°$	1	*107904.93*	${}^3P_1$
	$1°$	1	*110945.14*	
	$2°$	2	*112795.15*	
	$3°$	3	*113716.65*	
$5p^5\ ({}^2P_{\frac{1}{2}})\ 5d$ and $6s$	$4°$	1	*122872*	
	$5°$	1	*123645*	
$5p^5\ ({}^2P_{1\frac{1}{2}})\ 6p$	1	1	126518.54	
	2	2	128089.83	
	3	3	129107.65	
	4	1	129989.72	
	5	2	130766.00	
	6	0	133153.54	
$5p^5\ ({}^2P_{1\frac{1}{2}})\ 6d$ and $7s$	$10°$	2	*149212.24*	$({}^2P_{1\frac{1}{2}})\ 7s\ {}^3P_2$
	$11°$	1	*149605.32*	${}^3P_1$
	$1°$	1	*152172.11*	
	$2°$	2	*152791.47*	
	$3°$	2	*153302.26*	
	$4°$	3	*153556.59*	
	$5°$	3	*153678.19*	
	$6°$	1	*156399.34*	
$5p^5\ ({}^2P_{\frac{1}{2}})\ 6d$ and $7s$	$7°$	1	*163180*	

Cu I $Z = 29$

29 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 7.68 volts

These terms of the arc spectrum of copper have kindly been communicated by Dr. Shenstone. Most of the lower terms are established with great accuracy by means of precision measurements by Burns. The absolute term values are based on the series calculations of Fowler and, in the light of more recent data, might be increased by about 8 cm.$^{-1}$. There are many terms based on the $3d^9\,4s$ configuration of Cu II and the majority of these are higher than the first ionization potential and therefore appear in the term table with negative values. The limits to which they converge are $3d^9\,4s\ {}^3D_3 - 21925$; ${}^3D_2 - 22843.5$; ${}^3D_1 - 23994.7$; and ${}^1D_2 - 26260.7$ with respect to the $3d^{10}\ {}^1S_0$ as zero.

Nearly all terms from the $3d^9\,4s\,4d$ configuration have been found, with only six levels missing out of thirty-six.

References

A. G. Shenstone, unpublished material; *Phys. Rev.* **28,** 449 (1926); **34** 1623 (1929).

L. A. Sommer, *Zeits. f. Physik* **39,** 711 (1926). Zeeman effect.

C. S. Beals, *Proc. Roy. Soc.* **A111,** 168 (1926).

P. K. Kichlu, *Zeits. f. Physik* **39,** 572 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^{10}\,4s$	${}^2S$	$\frac{1}{2}$	62308.000	
$3d^9\,4s^2$	${}^2D$	$2\frac{1}{2}$ $1\frac{1}{2}$	51105.435 49062.577	−2042.858
$3d^{10}\,4p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*31772.698* *31524.314*	248.384
$3d^9\,4s\,4p$	${}^4P^\circ$	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*23289.348* *22194.01* *21364.27*	−95.338 −829.74

COPPER I

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9\ 4s\ 4p$	$^4F^\circ$	$4\frac{1}{2}$ $3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$	*21398.862* *21154.567* *20745.105* *20005.53*	−244.295 −409.462 −739.575
$3d^{10}\ 5s$	^2S	$\frac{1}{2}$	19170.791	
$3d^9\ 4s\ 4p$	$^4D^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*18794.05* *17901.732* *17763.847* *17392.39*	−892.318 −137.885 −371.457
$3d^9\ 4s\ 4p$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*18581.809* *17344.777*	1237.032
$3d^9\ 4s\ 4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*16487.00* *16428.689*	58.311
$3d^9\ 4s\ 4p$	$^2D^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$	*16135.158* *15709.66*	425.498
$3d^{10}\ 5p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*12925.05*	
$3d^{10}\ 4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	12372.800 12365.943	6.857
$3d^{10}\ 6s$	^2S	$\frac{1}{2}$	9459.251	
$3d^{10}\ 6p$	$^2P^\circ$	$1\frac{1}{2}$ $\frac{1}{2}$	*7523.94* *7280.26*	−243.57
$3d^{10}\ 5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	6920.332 6916.708	3.624
$3d^{10}\ 4f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	6881.8 6878.2	−3.6
$3d^9\ 4s\ 4p$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*6278.05* *4188.72*	−2089.33
$3d^9\ 4s\ 4p$	$^2P^\circ$	$1\frac{1}{2}$ $\frac{1}{2}$	*5964.26* *3943.27*	−2020.99
$3d^9\ 4s\ 4p$	$^2D^\circ$	$2\frac{1}{2}$ $1\frac{1}{2}$	*5656.52* *3617.14*	−2039.38
$3d^{10}\ 7s$	^2S	$\frac{1}{2}$	5636.613	

(Continued)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^{10}\,7p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*4888.69* *4359.29*	529.40
$3d^{10}\,6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	4415.5 4413.4	2.1
$3d^{10}\,5f$	$^2F^{\circ}$	$2\frac{1}{2}, 3\frac{1}{2}$	*4402.79*	
$3d^{10}\,8s$	^2S	$\frac{1}{2}$	3739.08	
$3d^{10}\,7d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	3059.7	
$3d^{10}\,6f$	$^2F^{\circ}$	$2\frac{1}{2}, 3\frac{1}{2}$	*3047.8*	
$3d^{10}\,8p$	$^2P^{\circ}$	$1\frac{1}{2}$ $\frac{1}{2}$	*3032.1* *2984.2*	−47.9
$3d^{10}\,9s$	^2S	$\frac{1}{2}$	2660.3	
$3d^{10}\,8d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	2241.9	
$3d^{10}\,7f$	$^2F^{\circ}$	$2\frac{1}{2}, 3\frac{1}{2}$	*2237.7*	
$3d^{10}\,9d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	1713.3	
$3d^{10}\,8f$	$^2F^{\circ}$	$2\frac{1}{2}, 3\frac{1}{2}$	*1706.8*	
$3d^9\;4s\;(^3D)\;5s$	^4D	$3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	−95.2 −640.2 −1276.4 −2164.2	−545.0 −636.2 −887.8
$3d^9\;4s\;(^3D)\;5s$	^2D	$2\frac{1}{2}$ $1\frac{1}{2}$	−2349.5 −2951.7	−602.2
$3d^9\;4s\;(^1D)\;5s$	^2D	$2\frac{1}{2}$ $1\frac{1}{2}$	−4834.3 −5663.9	−829.6
$3d^9\;4s\;(^3D_3)\;4d$	1 2 3 4 5 6 7 8 9	$1\frac{1}{2}$ $4\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $5\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	−8545.9 −8551.5 −8690.0 −8790.2 −8819.7 −8822.6 −8870.1 −8960.1 −8982.4	^2P ^2G ^4S ^2D ^2F ^4G ^4P ^4D ^4F

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9\ 4s\ (^3D_2)\ 4d$	11	$\frac{1}{2}$	−9574.9	^4P
	12	$1\frac{1}{2}$	−9619.1	^4P
	13	$4\frac{1}{2}$	−9670.7	^4G
	14	$3\frac{1}{2}$	−9708.6	^2G
	15	$2\frac{1}{2}$	−9758.9	^4D
	16	$3\frac{1}{2}$	−9785.0	^4F
	17	$\frac{1}{2}$	−9796.8	^4D
	18	$1\frac{1}{2}$	−9843.1	^4D
$3d^9\ 4s\ (^3D_1)\ 4d$	21	$3\frac{1}{2}$	−10794.6	^4G
	22	$\frac{1}{2}$	−10796.8	^2S
	23	$2\frac{1}{2}$	−10890.7	^4G
	24	$2\frac{1}{2}$	−10996.5	^4F
	25	$1\frac{1}{2}$	−11008.4	^4F
$3d^9\ 4s\ (^3D)\ 6s$	^4D	$3\frac{1}{2}$	−11687.0	
		$2\frac{1}{2}$	−12004.6	−317.16
		$1\frac{1}{2}$	—	
		$\frac{1}{2}$	−13436.4	
$3d^9\ 4s\ (^3D)\ 6s$	^2D	$2\frac{1}{2}$	−12862.0	Designation ?
		$1\frac{1}{2}$	−14024.0	
$3d^9\ 4s\ (^1D)\ 4d$	1	$\frac{1}{2}$	−12801.3	^2P
	2	$1\frac{1}{2}$	−12955.4	^2P
	3	$\frac{1}{2}$	−13077.0	^2S
	4	$1\frac{1}{2}$	−13131.6	^2D
	5	$2\frac{1}{2}$	−13138.8	^2D
	6	$2\frac{1}{2}$	−13227.8	^2F
	7	$3\frac{1}{2}$	−13264.9	^2F
—	1	$1\frac{1}{2}$	−13949.7	
$3d^9\ 4s\ (^3D_3)\ 5d$	4	$2\frac{1}{2}$	−14651.7	^2D
	6	$5\frac{1}{2}$	−14706.0	^4G
	7	$2\frac{1}{2}$	−14722.0	^4P ?
	5	$3\frac{1}{2}$	−14760.1	^2F ?
	8	$3\frac{1}{2}$	−14772.4	^4D ?
$3d^9\ 4s\ (^3D_2)\ 5d$	12	$1\frac{1}{2}$	−15532.6	^4P
	13	$4\frac{1}{2}$	−15545.9	^4G
	14	$3\frac{1}{2}$	−15591.1	^2G
	15	$2\frac{1}{2}$	−15597.4	^4D
	16	$3\frac{1}{2}$	−15611.2	^4F
	18	$1\frac{1}{2}$	−15651.3	^4D

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9\ 4s\ (^3D)\ 7s$	^4D	$3\frac{1}{2}$	−15952.2	−593.8
		$2\frac{1}{2}$	−16546.0 ?	
		$1\frac{1}{2}$	—	
		$\frac{1}{2}$	−18022.4	
—	2	$1\frac{1}{2}$	−16269.7 ?	
$3d^9\ 4s\ (^3D_1)\ 5d$	21	$3\frac{1}{2}$	−16680.1	^4G
	23	$2\frac{1}{2}$	−16745.0 ?	^4G
	24	$2\frac{1}{2}$	−16807.8	^4F
—	3	$2\frac{1}{2}$	−16950.1 ?	
$3d^9\ 4s\ (^3D_3)\ 6d$	6	$5\frac{1}{2}$	−17361.0	^4G
	8	$3\frac{1}{2}$	−17393.9	^4D
$3d^9\ 4s\ (^3D)\ 8s$	^4D	$3\frac{1}{2}$	−18009.7	
$3d^9\ 4s\ (^3D_2)\ 6d$	13	$4\frac{1}{2}$	−18196.5	^4G
—	4	$2\frac{1}{2}$	−18232.6 ?	
	5	$1\frac{1}{2}$	−18778.1 ?	
$3d^9\ 4s\ (^1D)\ 5d$	4	$1\frac{1}{2}$	−19006.0	^2D
	6	$2\frac{1}{2}$	−19054.6	^2F
$3d^9\ 4s\ (^3D)\ 9s$	^4D	$3\frac{1}{2}$	−19159.5 ?	

Cu II $Z = 29$

28 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\ {}^1S_0$

First ionization potential = 20.2 volts

This classification has been given for the greater part by Shenstone. Kruger has found higher members of the $3d^9\, ms$ series and also published some higher $3d^9\, mp$ terms which he has kindly informed us are probably in part incorrect, and they have therefore been omitted from this table.

The absolute value of the lowest state is 163634 cm.$^{-1}$ with respect to $3d^9\ {}^2D_{2\frac{1}{2}}$ of Cu III.

References

A. G. Shenstone, *Phys. Rev.* **28,** 382 (1927). Also unpublished material.
R. J. Lang, *Phys. Rev.* **31,** 773 (1928).
A. C. Menzies, *Proc. Roy. Soc.* **A119,** 249 (1928).
P. G. Kruger, *Phys. Rev.* **34,** 1122 (1929).

Configuration	Symbol	J	Term value	
$3d^{10}$	^1S	0	0	
$3d^9\ ({}^2D_{2\frac{1}{2}})\ 4s$	1	3	21925.0	$^3D_3$
	2	2	22843.5	$^3D_2$
$({}^2D_{1\frac{1}{2}})\ 4s$	3	1	23994.7	$^3D_1$
	4	2	26260.7	$^1D_2$
$3d^9\ ({}^2D)\ 4p$	1°	2	*66414.9*	
	2°	1	*67912.8*	
	3°	3	*68444.1*	
	4°	4	*68727.1*	
	5°	0	*68846.2*	
	6°	2	*69864.3*	
	7°	3	*70837.5*	
	8°	2	*71489.9*	

(*Concluded*)

Configuration	Symbol	J	Term value	
$3d^9\,(^2D)$ $4p$	9°	3	*71916.3*	
	10°	1	*73098.3*	
	11°	2	*73349.3*	
	12°	1	*73592.1*	
$3d^9\,(^2D)$ $4d$	1	1	92582.8	
	2	5	93640.6	
	3	2	93710.4	
	4	4	93733.9	
	5	1	93736.7	
	6	3	94151.7	
	7	3	94397.6	
	8	4	94442.7	
	9	2	94459.3	
	10	0	94808.7?	
	11	1	95303.1	
	12	3	95819.1	
	13	4	95954.9	
	14	1	96234.8	
	15	2	96244.3?	
	16	3	96555.4	
	17	2	96603.5	
	18	0	97508.8?	
$3d^9\,(^2D_{2\frac{1}{2}})\,5s$	1	3	108008.7	$^3D_3$
	2	2	108329.6	$^3D_2$
$(^2D_{1\frac{1}{2}})\,5s$	3	1	110078.3	$^3D_1$
	4	2	110360.0	$^1D_2$
$3d^9\,(^2D_{2\frac{1}{2}})\,6s$	1	3	133589.5	$^3D_3$
	2	2	133723.4	$^3D_2$
$(^2D_{1\frac{1}{2}})\,6s$	3	1	135659.1	$^3D_1$
	4	2	135754.8	$^1D_2$
$3d^9\,(^2D_{2\frac{1}{2}})\,7s$	1	3	144808.3	$^3D_3$
	2	2	144877.9	$^3D_2$
$(^2D_{1\frac{1}{2}})\,7s$	3	1	146879.5	$^3D_1$
	4	2	146930.5	$^1D_2$

F I $\qquad Z = 9$

9 electrons $\qquad 1s^2\,2s^2\,2p^5\;{}^2P_{1\frac{1}{2}}^{\circ}$

First ionization potential = 18.6 volts

The analysis of this spectrum has been given by Dingle and by De Bruin; Dingle's data are used here.

Three different tables have to be given, as Dingle found three term systems between which no intercombinations are yet known.

The first table contains the normal state $2s^2\,2p^5\;{}^2P_{1\frac{1}{2}}^{\circ}$, the state $2s\,2p^6\;{}^2S$, and states built upon the $2p^4\;{}^3P$ of F II.

The second table contains states built upon the $2p^4\;{}^1D$ of F II, the lowest of which is $2p^4\,({}^1D)\,3s\;{}^2D$. It also contains two terms 1 and 2, which lie lower than this last one and must be built on the $2p^4\,({}^3P)$ configuration of F II.

The third table contains three levels which are built upon $2p^4\,({}^1S)$ according to Dingle. It must be remarked that the reality of the terms in the second and third tables, as well as their assignments, is not certain.

The absolute value of the lowest state $2p^5\;{}^2P_{1\frac{1}{2}}^{\circ}$ is given as about 150959 cm.$^{-1}$ with respect to the $3p^4\;{}^3P$ of F II.

References

T. L. de Bruin, *Zeits. f. Physik* **39**, 869 (1926).

I. S. Bowen, *Phys. Rev.* **29**, 231 (1927). Lowest state from ultra-violet observations.

H. Dingle, *Proc. Roy. Soc.* **117**, 407 (1928). Classified lines.

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^5$	${}^2P^{\circ}$	$1\frac{1}{2}$	0	
		$\frac{1}{2}$	407.0	−407.0
$2p^4\,({}^3P)\,3s$	${}^4P$	$2\frac{1}{2}$	102412.0	
		$1\frac{1}{2}$	102686.7	−274.7
		$\frac{1}{2}$	102846.7	−160.0

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^4\ (^3P)\ 3s$	^2P	$1\frac{1}{2}$	104737.6	−325.3
		$\frac{1}{2}$	105062.9	
$3p$	$^4P^\circ$	$2\frac{1}{2}$	*115924.2*	−122.9
		$1\frac{1}{2}$	*116047.1*	−102.7
		$\frac{1}{2}$	*116149.8*	
$3p$	$^4D^\circ$	$3\frac{1}{2}$	*116993.6*	−176.6
		$2\frac{1}{2}$	*117170.2*	−144.5
		$1\frac{1}{2}$	*117314.7*	−83.4
		$\frac{1}{2}$	*117398.1*	
$3p$	$^2D^\circ$	$2\frac{1}{2}$	*117629.1*	−249.9
		$1\frac{1}{2}$	*117879.0*	
$3p$	$^2S^\circ$	$\frac{1}{2}$	*118411.8*	
$3p$	$^4S^\circ$	$1\frac{1}{2}$	*118434.0*	
$3p$	$^2P^\circ$	$1\frac{1}{2}$	*118943.2*	−145.0
		$\frac{1}{2}$	*119088.2*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^4\ (^1D)\ 3s$	^2D	$2\frac{1}{2}$	0	−116.2
		$1\frac{1}{2}$	116.2	
$3p$	$^2P^\circ$	$1\frac{1}{2}$	*12216.5*	−99.4
		$\frac{1}{2}$	*12315.9*	
$3p$	$^2D^\circ$	$2\frac{1}{2}$	*14922.8*	−77.1
		$1\frac{1}{2}$	*14999.9*	
—	1	$1\frac{1}{2}$	−2417.5	−43.0
	2	$\frac{1}{2}$	−2374.5	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^4\ (^1S)\ 3s$	^2S	$\frac{1}{2}$	0	
$3p$	$^2P^\circ$	$1\frac{1}{2}$	*13668.0*	−9.8
		$\frac{1}{2}$	*13677.8*	

F II $Z = 9$

8 electrons $1s^2\,2s^2\,2p^4\;{}^3P_2$

First ionization potential = 34.6 volts

The classification is given by Dingle. Separate tables are given for the quintets, triplets, and singlets, because no intercombinations have been found. There are two tables for the singlets, one for those built upon $2p^3\;{}^2D$ and one for those built upon $2p^3\;{}^2P$ of F III. The triplets arise also from different states of F III and, as combinations between terms built upon different states are scarce, the relative position of these triplet terms is not quite certain.

The absolute values, referred to $2p^3\;{}^4S_{1\frac{1}{2}}$ of F III for the lowest level in each table are:

$2p^4\;{}^3P_2$	280193 cm.$^{-1}$
$2p^3\;({}^4S)\;3s\;{}^5S_2^\circ$	*105536*
$2p^3\;({}^2D)\;3s\;{}^1D_2^\circ$	*65200*
$2p^3\;({}^2P)\;3s\;{}^1P_1^\circ$	*50435*

Reference

H. Dingle, *Proc. Roy. Soc.* **A128**, 600 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^3\;({}^4S)\;3s$	${}^5S^\circ$	2	*0*	
$2p^3\;({}^4S)\;3p$	${}^5P$	1 2 3	25955.45 25966.78 25986.33	11.33 19.55
$2p^3\;({}^4S)\;3d$	${}^5D^\circ$	4 3 2 1 0	*54503.88* *54504.79* *54505.99* *54506.67* *54507.19*	−0.91 −1.20 −0.68 −0.52
$2p^3\;({}^4S)\;4s$	${}^5S^\circ$	2	*58656.95*	
$2p^3\;({}^4S)\;4f$	${}^5F$	1–5	78048.9	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^4$	^3P	2	0	
				−344
		1	344	
				−147
		0	491	
$2s\ 2p^5$	$^3P^\circ$	2	*164798*	
				−306
		1	*165104*	
				−183
		0	*165287*	
$2s^2\ 2p^3\ (^4S)\ 3s$	$^3S^\circ$	1	*182868.00*	
$2s^2\ 2p^3\ (^4S)\ 3p$	^3P	1	207702.71	
		0	207705.71	
		2	207707.41	
$2p^3\ (^2D)\ 3s$	$^3D^\circ$	3	*211869.42*	
				−21.07
		2	*211890.49*	
				−13.03
		1	*211903.52*	
$2p^3\ (^2P)\ 3s$	$^3P^\circ$	2	*230074.63*	
				−1.61
		1	*230076.24*	
				−2.66
		0	*230078.90*	
$2p^3\ (^4S)\ 3d$	$^3D^\circ$	1	*232066.98*	
				0.80
		2	*232067.78*	
				2.08
		3	*232069.86*	
$2p^3\ (^2D)\ 3p$	^3D	1	236182.15	
				2.72
		2	236175.87	
				22.50
		3	236198.37	
$2p^3\ (^4S)\ 4s$	$^3S^\circ$	1	*236964.43*	
$2p^3\ (^2D)\ 3p$	^3F	4	237510.71	
				−0.81
		3	237511.52	
				−0.65
		2	237512.17	
$2p^3\ (^2D)\ 3p$	^3P	2	240095.90	
				−60.24
		1	240156.35	
				−26.57
		0	240182.71	
—	^3P	0	246657.90	
				7.45
		1	246665.35	
				20.12
		2	246685.47	
$2p^3\ (^2P)\ 3p$	^3S	1	253837.00	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^3\ (^2P)\ 3p$	^3D	3	255226.10	
				−15.06
		2	255241.16	
				−6.60
		1	255247.76	
$2p^3\ (^2P)\ 3p$	^3P	0	257777.7	
				14.9
		1	257792.6	
				23.9
		2	257816.5	
$2p^3\ (^2D)\ 3d$?	$^3G^\circ$?	3, 4, 5	*264497.5*	
$2p^3\ (^2D)\ 3d$?	$^3F^\circ$	2	*264955.92*	
				5.51
		3	*264961.43*	
				7.28
		4	*264968.71*	
$2p^3\ (^2D)\ 3d$	$^3D^\circ$	3	*265475.50*	
				−26.04
		2	*265501.54*	
				−18.40
		1	*265519.94*	
$2p^3\ (^2D)\ 3d$	$^3S^\circ$	1	*266363.49*	
$2p^3\ (^2D)\ 3d$	$^3P^\circ$	2	*266457.07*	
				−44.85
		1	*266501.92*	
				−17.23
		0	*266519.15*	
$2p^3\ (^2P)\ 3d$	$^3F^\circ$	2, 3, 4	*278611.6*	
$2p^3\ (^2P)\ 3d$	$^3P^\circ$	0	*283420.8*	
				16.4
		1	*283437.2*	
				34.5
		2	*283471.7*	
$2p^3\ (^2P)\ 3d$	$^3D^\circ$	3	*287225.7*	
				−4.7
		2	*287230.4*	
				−0.7
		1	*287231.1*	

Configuration	Symbol	J	Term value
$2p^3\ (^2D)\ 3s$	$^1D^\circ$	2	*0*
$2p^3\ (^2D)\ 3p$	^1F	3	20573.3
$2p^3\ (^2D)\ 3p$	^1P	1	23253.8
$2p^3\ (^2D)\ 3p$	^1D	2	31214.1

(*Concluded*)

Configuration	Symbol	J	Term value
$2p^3\ (^2D)\ 3d$	$^1D^\circ$	2	*51200.4*
$2p^3\ (^2D)\ 3d$	$^1P^\circ$	1	*51478.9*
$2p^3\ (^2D)\ 3d$	$^1F^\circ$	3	*52330.5*
$2p^3\ (^2D)\ 4s$	$^1D^\circ$	2	*55438.6*

Configuration	Symbol	J	Term value
$2p^3\ (^2P)\ 3s$	$^1P^\circ$	1	*0*
—	1°	1	*4533.1*
$2p^3\ (^2P)\ 3p$	^1S	0	28377.8
$2p^3\ (^2P)\ 3p$	^1P	1	31701.8
$2p^3\ (^2P)\ 3p$	^1D	2	39110.2
$2p^3\ (^2P)\ 3d$	$^1P^\circ$	1	*56996.6*
$2p^3\ (^2P)\ 3d$	$^1D^\circ$	2	*58435.2*

F III $\qquad Z = 9$

7 electrons $\qquad 1s^2\, 2s^2\, 2p^3\ {}^4S_{1\frac{1}{2}}^{\circ}$.

In the second spark spectrum of fluorine, the transitions $2s\, 2p^4 \rightarrow 2s^2\, 2p^3$ were first found by Bowen, but no intercombinations have been found. More recently, Dingle has found many new terms (again without intercombinations), but has not been able to connect these levels with the low levels found by Bowen. This necessitates the use of four separate term tables.

In the doublets, the combinations $3d\ {}^2P$ with $3p\ {}^2P^{\circ}$ and $3p\ {}^2D^{\circ}$ are not found, which makes both $3d\ {}^2P$ and $3s\ {}^2P$ uncertain. From Bowen's lines, two lines at 152047 and 95271 seem possible for the combinations $2s\, 2p^4\ {}^2D$ and ${}^2P$ with $2p^2\, 3p\ {}^2P^{\circ}$, which would set $2p^2\, 3s\ {}^2P_{\frac{1}{2}}$ at 116114 with respect to $2p^3\ {}^2D^{\circ}$.

References

I. S. Bowen, *Phys. Rev.* **29**, 231, 1927.
H. Dingle, *Proc. Roy. Soc.* **A122**, 144 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\, 2p^3$	${}^4S^{\circ}$	$1\frac{1}{2}$	*0*	
$2s\ \ 2p^4$	${}^4P$	$2\frac{1}{2}$	151897	
		$1\frac{1}{2}$	152239	−342
		$\frac{1}{2}$	152416	−177

$2s^2\, 2p^2\, ({}^3P)\, 3s$	${}^4P$	$\frac{1}{2}$	0	
		$1\frac{1}{2}$	211.3	211.3
		$2\frac{1}{2}$	530.2	318.9
$3p$	${}^4D^{\circ}$	$\frac{1}{2}$	*31993.2*	
		$1\frac{1}{2}$	*32108.1*	114.9
		$2\frac{1}{2}$	*32297.8*	189.7
		$3\frac{1}{2}$	*32556.7*	258.9

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^2\,(^3P)\,3p$	$^4P^\circ$	$\frac{1}{2}$	*34526.8*	
		$1\frac{1}{2}$	*34621.1*	94.3
		$2\frac{1}{2}$	*34809.8*	188.7
$3d$	^4F	$1\frac{1}{2}$	70550.0	
		$2\frac{1}{2}$	70658.9	108.9
		$3\frac{1}{2}$	70814.9	156.0
		$4\frac{1}{2}$	71018.2	203.3
$3d$	^4D	$\frac{1}{2}$	73411.1	
		$1\frac{1}{2}$	73371.0	−40.1
		$2\frac{1}{2}$	73368.4	−2.6
		$3\frac{1}{2}$	73501.1	132.7
$3d$	^4P	$\frac{1}{2}$	74337.9	
		$1\frac{1}{2}$	74266.7	71.2
		$2\frac{1}{2}$	74125.0	141.7

$2s^2\,2p^3$	$^2D^\circ$	$1\frac{1}{2}, 2\frac{1}{2}$	*0*	
	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*17462*	
$2s\,2p^4$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	176149	
	^2P	$1\frac{1}{2}$	232479	
		$\frac{1}{2}$	232869	−390

$2s^2\,2p^2\,(^3P)\,3s$	^2P	$\frac{1}{2}$	0	
		$1\frac{1}{2}$	385.4	385.4
$3p$	$^2D^\circ$	$1\frac{1}{2}$	*31489.7*	
		$2\frac{1}{2}$	*31880.1*	390.4
$3p$	$^2P^\circ$	$\frac{1}{2}$	*35856.3*	
		$1\frac{1}{2}$	*35943.2*	86.9
$3p$	$^2S^\circ$	$\frac{1}{2}$	*36897.3*	
$3d$	^2F	$2\frac{1}{2}$	66765.7	
		$3\frac{1}{2}$	67135.6	369.9
$3d$	^2D	$1\frac{1}{2}$	70776.2	
		$2\frac{1}{2}$	70894.2	118.0
$3d$	^2P	$1\frac{1}{2}$	81982.4	
		$\frac{1}{2}$	82194.8	−212.4

F IV $Z = 9$

6 electrons $1s^2\,2s^2\,2p^2\;{}^3P_0$

This classification has been given by Bowen and has been found by extrapolation of a group of isoelectronic spectra.

Reference

I. S. Bowen, *Phys. Rev.* **29**, 231 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^2$	${}^3P$	0 1 2	0 233 415	233 182
$2s\;2p^3$	${}^3D^\circ$	1, 2, 3	*147916*	
$2s\;2p^3$	${}^3P^\circ$	0, 1, 2	*175245*	
$2s\;2p^3$	${}^3S^\circ$	1	*238124*	

Fe I $Z = 26$

26 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s^2\ {}^5D_4$

First ionization potential = 7.83 volts

The classification of this complicated spectrum by Laporte was one of the first triumphs of the modern theory of spectra. The terms in this paper have been taken from the very complete paper by Burns and Walters. For a few multiplets the assignment of electron configurations is not quite certain.

The absolute value of the lowest state is about 63400 cm.$^{-1}$ with respect to $3d^6\,4s\ {}^6D_{4\frac{1}{2}}$ of Fe II.

Even multiplets of the same kind have been lettered *a*, *b*, *c*, . . . in order of occurrence; the odd ones, *z*, *y*, *x*, . . . To facilitate reference to the classified lines of Burns and Walters, the "name" which they gave to unassigned levels has been included in the last column.

References

F. M. Walters, *Journ. Wash. Acad. Sci.* **13,** 243 (1923). First multiplets.

O. Laporte, *Zeits. f. Physik* **23,** 135 (1924). Classification. *Zeits. f. Phys.* **26,** 1 (1924). Classification. *Proc. Nat. Acad. Sci.* **12,** 496 (1926). Discussion of classification; additional references.

W. F. Meggers, *Astrophys. Journ.* **60,** 60 (1924). Connection between classification and standard wave lengths.

H. N. Russell, *Journ. Opt. Soc. Am.* **8,** 245 (1924). Ionization potentials.

C. E. Moore and H. N. Russell, *Astrophys. Journ.* **68,** 151 (1928). Term table.

K. Burns and F. M. Walters, *Publications, Allegheny Observatory,* vol. VI, no. 11, p. 159 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^6\,4s^2$	$a\ {}^5D$	4	0.000	
				−415.934
		3	415.934	
				−288.067
		2	704.001	
				−184.125
		1	888.126	
				−89.942
		0	978.068	

(*Continued*)

Configuration	Symbol	*J*	Term value	Δν
$3d^7\ (^4F)\ 4s$	$a\ ^5F$	5	6928.272	−448.500
		4	7376.772	−351.296
		3	7728.068	−257.723
		2	7985.791	−168.926
		1	8154.717	
$3d^7\ (^4F)\ 4s$	$a\ ^3F$	4	11976.251	−584.697
		3	12560.948	−407.622
		2	12968.570	
$3d^7\ (^4P)\ 4s$	$a\ ^5P$	3	17550.207	−176.804
		2	17727.011	−200.397
		1	17927.408	
—	$a\ ^3P$	2	18378.215	−1174.278
		1	19552.493	−485.351
		0	20037.844	
$3d^6 4s\ (^6D)\ 4p$	$z\ ^7D^\circ$	5	*19350.899*	−211.558
		4	*19562.457*	−194.580
		3	*19757.037*	−155.473
		2	*19912.510*	−107.144
		1	*20019.654*	
$3d^7\ (^2H)\ 4s$	$a\ ^3H$	6	19390.197	−230.839
		5	19621.036	−167.244
		4	19788.280	
$3d^6\ 4s^2$	$b\ ^3F$	4	20641.144	−233.377
		3	20874.521	−164.500
		2	21039.021	
$3d^6\ 4s^2$	$a\ ^3G$	5	21715.770	−283.397
		4	21999.167	−250.294
		3	22249.461	
$3d^6 4s\ (^6D)\ 4p$	$z\ ^7F^\circ$	6	*22650.447*	−195.442
		5	*22845.889*	−150.807
		4	*22996.696*	−114.256
		3	*23110.952*	−81.564
		2	*23192.516*	−52.339
		1	*23244.855*	−25.550
		0	*23270.405*	
$3d^7\ (^4P)\ 4s$	$b\ ^3P$	2	22838.360	−108.500
		1	22946.860	−104.930
		0	23051.790	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^6 4s\ (^6D)\ 4p$	$z\ ^7P^\circ$	4	*23711.475*	
		3	*24180.884*	−469.409
		2	*24506.939*	−326.055
$3d^7\ (^2G)\ 4s$	$b\ ^3G$	5	23783.654	
		4	24118.854	−335.200
		3	24338.805	−219.951
—	1	2	24335.804	3M
	2	4	24574.690	2M
	3	2	24772.060	4M
$3d^6 4s\ (^6D)\ 4p$	$z\ ^5D^\circ$	4	*25900.003*	
		3	*26140.198*	−240.195
		2	*26339.709*	−199.511
		1	*26479.394*	−139.685
		0	*26550.492*	−71.098
$3d^6 4s\ (^6D)\ 4p$	$z\ ^5F^\circ$	5	*26874.570*	
		4	*27166.841*	−292.271
		3	*27394.710*	−227.869
		2	*27559.603*	−164.893
		1	*27666.363*	−106.760
$3d^6 4s\ (^6D)\ 4p$	$z\ ^5P^\circ$	3	*29056.352*	
		2	*29469.044*	−412.692
		1	*29732.758*	−263.714
$3d^6 4s\ (^4D)\ 4p$	$z\ ^3F^\circ$	4	*31307.277*	
		3	*31805.100*	−497.823
		2	*32134.020*	−328.920
$3d^6 4s\ (^4D)\ 4p$	$z\ ^3D^\circ$	3	*31322.637*	
		2	*31686.380*	−363.743
		1	*31937.353*	−250.973
$3d^7\ (^4F)\ 4p$	$y\ ^5D^\circ$	4	*33095.976*	
		3	*33507.161*	−411.185
		2	*33801.608*	−294.447
		1	*34017.136*	−215.528
		0	*34121.633*	−104.497
$3d^7\ (^4F)\ 4p$	$y\ ^5F^\circ$	5	*33695.429*	
		4	*34039.548*	−344.119
		3	*34328.787*	−289.239
		2	*34547.243*	−218.456
		1	*34692.177*	−144.934

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^6\,4s\,(^4D)\,4p$	$z\ ^3P^\circ$	2	*33947.965*	
				−414.925
		1	*34362.890*	
				−192.731
		0	*34555.621*	
$3d^7\,(^4F)\,4p$	$z\ ^5G^\circ$	6	*34843.984*	
				61.530
		5	*34782.454*	
				−474.897
		4	*35257.351*	
				−354.305
		3	*35611.656*	
				−244.775
		2	*35856.431*	
$3d^7\,(^4F)\,4p$	$z\ ^3G^\circ$	5	*35379.246*	
				−388.357
		4	*35767.603*	
				−311.808
		3	*36079.411*	
$3d^7\,(^4F)\,4p$	$y\ ^3F^\circ$	4	*36686.217*	
				−476.570
		3	*37162.787*	
				−358.414
		2	*37521.201*	
$3d^6\,4s\,(^4D)\,4p$	$y\ ^5P^\circ$	3	*36767.007*	
				−390.597
		2	*37157.604*	
				−251.979
		1	*37409.583*	
$3d^7\,(^4F)\,4p$	$y\ ^3D^\circ$	3	*38175.391*	
				−502.684
		2	*38678.075*	
				−317.696
		1	*38995.771*	
$3d^6\,4s\,(^4D)\,4p$	$x\ ^5D^\circ$	4	*39625.847*	
				−344.049
		3	*39969.896*	
				−241.482
		2	*40231.378*	
				−173.183
		1	*40404.561*	
				−86.768
		0	*40491.329*	
$3d^7\,(^4P)\,4p$	$z\ ^5S^\circ$	2	*40895.036*	
$3d^6\,4s\,(^4D)\,4p$	$x\ ^5F^\circ$	5	*40257.367*	
				−337.086
		4	*40594.453*	
				−247.732
		3	*40842.185*	
				−175.871
		2	*41018.056*	
				−112.607
		1	*41130.663*	
$3d^7\,(^4P)\,4p$	$x\ ^5P^\circ$	3	*42532.795*	
				−327.034
		2	*42859.829*	
				−219.252
		1	*43079.081*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$y\ ^5G^\circ$	6	*42784.387*	
		5	*42911.918*	−127.531
		4	*43022.998*	−111.080
		3	*43137.511*	−114.513
		2	*43210.044*	−72.533
$3d^6\ 4s\ (^6D)\ 5s$	$a\ ^7D$	5	42815.890	
		4	43163.360	−347.470
		3	43434.662	−271.302
		2	43633.566	−198.904
		1	43764.017	−130.451
$3d^7\ (^4P)\ 4p$	$w\ ^5D^\circ$	4	*43499.534*	
		3	*43922.722*	−423.188
		2	*44183.676*	−260.954
		1	*44411.224*	−227.548
		0	*44458.90*	−47.676
—	4°	5	*43600.49*	54R
	5°	4	*44022.60*	53R
	6°	3	*44166.29*	52R
	7°	5	*44243.72*	$^5F^\circ$ 50R
	8°	2	*44285.52*	45R
	9°	4	*44415.12*	$^5F^\circ$ 49R
	10°	2	*44511.888*	$^5S^\circ$ 55R
	11°	3	*44551.41*	$^5F^\circ$ 48R
	12°	2	*44664.12*	$^5F^\circ$ 51R
$3d^6\ 4s\ (^6D)\ 5s$	$b\ ^5D$	4	44677.035	
		3	45061.360	−384.325
		2	45333.905	−272.545
		1	45509.182	−175.277
		0	45595.112	−85.930
—	13°	1	*44760.85*	$^5F^\circ$ 47R
—	14°	2	*45024.23*	46R
—	$x\ ^3D^\circ$	3	*45220.738*	
		2	*45281.889*	−61.151
		1	*45551.833*	−269.944
$3d^7\ 4p$	$y\ ^3G^\circ$	5	*45294.902*	
		4	*45428.456*	−133.554
		3	*45563.026*	−134.570

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$x\ ^5G^\circ$	6	*45608.38*	−117.86
		5	*45726.24*	−107.03
		4	*45833.27*	−80.26
		3	*45913.53*	−51.48
		2	*45965.01*	
—	$w\ ^5P^\circ$	3	*46137.10*	−176.50
		2	*46313.60*	−96.86
		1	*46410.46*	
—	15°	1	*46600.884*	20R
	16°	4	*46720.900*	18R
$3d^7\ (^4P)\ 4p$	$y\ ^3P^\circ$	2	*46727.137*	−174.755
		1	*46901.892*	−269.668
		0	*47171.56*	
—	17°	3	*46745.056*	19R
	18°	2	*46888.582*	16R
	19°	4	*46889.207*	$^3F^\circ$ 15R
—	$z\ ^3H^\circ$	6	*46982.383*	−26.045
		5	*47008.428*	−98.116
		4	*47106.544*	
$3d^7\ (^4F)\ 5s$	$b\ ^5F$	5	47005.538	−372.453
		4	47377.991	−377.580
		3	47755.571	−281.131
		2	48036.702	−184.650
		1	48221.352	
$3d^7\ (^4P)\ 4p$	$w\ ^3D^\circ$	3	*47017.239*	−118.903
		2	*47136.142*	−135.953
		1	*47272.095*	
—	20°	3	*47092.776*	$^3F^\circ$ 12R
	21°	1	*47177.296*	10R
	22°	2	*47197.074*	$^3F^\circ$ 9R
	23°	2	*47419.747*	$^3D^\circ$ 7R
$3d^7\ (^4P)\ 4p$	$z\ ^3S^\circ$	1	*47555.677*	
—	24°	4	*47812.175*	24R
	25°	4	*47834.622*	26R

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	
$3d^7\ (^4F)\ 5s$	$c\ ^3F$	4	47960.973		
				−570.923	
		3	48531.896		
				−396.527	
		2	48928.423		
—	26°	3	47966.633	$^5P°$	6R
	27°	1	47976.60		44R
	28°	2	48163.509	$^5P°$	5R
	29°	—	48231.26		43R
	30°	2	48238.903		4R
	31°	1	48289.919	$^5P°$	3R
	32°	2	48304.707		2R
	33°	—	48361.92		42R
	34°	3, 4	48475.76		41R
	35°	1	48516.05		1R
	36°	—	48702.542		40R
	37°	4	49108.950		38R
	38°	3	49135.090		37R
	39°	—	49198.40		39R
	40°	3	49242.950		35R
	41°	1	49297.57		36R
	42°	6	49434.224	$^3H°$	34R
	43°	5	49460.970	$^3G°$	33R
	44°	5	49604.476	$^3H°$	31R
	45°	4	49627.941	$^3H°$	32R
	46°	2	49710.64		30R
	47°	4	49727.058	$^3G°$	29R
	48°	3	49850.69	$^3G°$	28R
	49°	2	50186.973	$^3P°$	56R
—	50	6	50342.180	^7F	53W
	51	5	50377.935	^7D	34W
	52	—	50423.185		33W
	55	5	50475.323	^7D, ^5D	58W
	54	6	50522.988		46W
	55	3	50534.435	^7D	32W
	56	3	50611.303		31W
	57	5	50657.28	^7D	30W
	58	3	50698.666		29W
	59	5	50703.912		28W
	60	4	50808.053	^7D	27W
	61	5	50833.485	^7D	25W
	62	3	50861.374	^7D	26W
	63	1	50880.152	^5D	22W
	64	2	50884.258	^7F	21W

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	
—	65	6	50967.873	^7F	23W
	66	3	50979.627		59W
	67	2	50998.686	^7P	20W
	68	2	51048.144		19W
	69	5	51103.237	^5F	18W
	70	3, 4	51148.892		17W
	71		51148.952		17W
	72	4	51192.320	^7P	16W
	73	1	51208.039	^7D	43W
	74	3	51219.059		14W
	75	4	51228.595	^7D	13W
$3d^6\,4s\,(^4D)\,5s$	$a\ ^3D$	3	51294.262	−445.702	
		2	51739.964	−299.975	
		1	52039.939		
—	76	2	51331.090	^7D	11W
	77	2	51370.184	^5F	9W
	78	4	51334.950		10W
$3d^6\,4s\,(^4D)\,5s$	$c\ ^5D$	4	51350.539	−420.064	
		3	51770.603	−279.274	
		2	52049.877	−164.519	
		1	52214.396	−42.993	
		0	52257.389		
—	79	2	51460.572		42W
	80	2	51461.707		8W
	81	1	51539.712	^7F	41W
	82	2	51570.153	^7P	7W
	83	3	51604.146	^5F	56W
	84	2	51705.052	^5F	6W
	85		51754.534		57W
	86	3	51837.239	^5P	4W
	87	2	51837.40	^5P	3W
	88	1	52019.706	^5P	2W
—	89°	1	*52512.44*		57R
	90	5, 6	53061.365	^5F	47W
	91	5	53155.194	^5F	36W
—	92		53169.190		48W
	93	4	53281.735	^5F	39W
	94	3	53393.715	^5F	37W

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$	
—	95	3	53545.882	^5F	38W
	96	2, 3	53568.812		62W
	97	3	53718.794		54W
—	$c\ ^3G$	5	53739.488		
				−327.086	
		4	54066.574		
				−312.859	
		3	54379.433		
—	98	3	53747.547	^3F, ^3D	55W
	99	3	53769.020	^5F	40W
	100	2, 3	53831.031		63W
	101	3	53966.720		61W
	102	2	54066.821		45W
	103	3, 4	54087.713		51W
	104	2, 3	54161.182	^5F, ^3F	49W
	105	1, 2	54257.562		64W
	106	2	54375.719	^5F	50W
—	$c\ ^3D$	3	54683.369		
				−441.605	
		2	55124.974		
				−253.868	
		1	55378.842		
—	107	3, 4	54721.36		52W
—	$c\ ^3P$	2	54879.720		
				−496.397	
		1	55376.117		

Fe II $\qquad Z = 26$

25 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^6\,4s\ {}^6D_{4\frac{1}{2}}$

First ionization potential = 16.5 volts.

This classification has been given according to Russell. The lowest state has been estimated to be 133,000 cm.$^{-1}$ with respect to the $3d^6\ {}^5D$ of Fe III.

References

H. N. Russell, *Astrophys. Journ.* **64,** 194 (1926). Term values and classified lines.

H. N. Russell, *Astrophys. Journ.* **66,** 233 (1927). Ionization potentials.

W. F. Meggers and F. M. Walters, Jr., Bur. Stand. Sci. Papers **22,** 205 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^6\,({}^5D)\,4s$	$a\ {}^6D$	$4\frac{1}{2}$	0	
				−384.80
		$3\frac{1}{2}$	384.80	
				−282.85
		$2\frac{1}{2}$	667.65	
				−194.90
		$1\frac{1}{2}$	862.55	
				−114.41
		$\frac{1}{2}$	976.96	
$3d^7$	$a\ {}^4F$	$4\frac{1}{2}$	1872.56	
				−557.60
		$3\frac{1}{2}$	2430.16	
				−407.75
		$2\frac{1}{2}$	2837.91	
				−279.58
		$1\frac{1}{2}$	3117.49	
$3d^6\,({}^5D)\,4s$	$a\ {}^4D$	$3\frac{1}{2}$	7955.24	
				−436.66
		$2\frac{1}{2}$	8391.90	
				−288.47
		$1\frac{1}{2}$	8680.37	
				−166.35
		$\frac{1}{2}$	8846.72	
$3d^7$	$a\ {}^4P$	$2\frac{1}{2}$	13474.36	
				−198.68
		$1\frac{1}{2}$	13673.04	
				−231.70
		$\frac{1}{2}$	13904.74	
$3d^6\,({}^3P)\,4s$	$b\ {}^4P$	$2\frac{1}{2}$	20830.44	
				−981.49
		$1\frac{1}{2}$	21811.93	
				−597.78
		$\frac{1}{2}$	22409.71	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^6\,(^3F)\,4s$	$b\,^4F$	$4\frac{1}{2}$	22637.15	
		$3\frac{1}{2}$	22810.28	−173.13
		$2\frac{1}{2}$	22939.21	−128.93
		$1\frac{1}{2}$	23031.25	−92.04
$3d^5\,4s^2$	$a\,^6S$	$2\frac{1}{2}$	23317.61	
$3d^6\,(^3G)\,4s$	$a\,^4G$	$5\frac{1}{2}$	25428.78	
		$4\frac{1}{2}$	25805.21	−376.43
		$3\frac{1}{2}$	25981.51	−176.30
		$2\frac{1}{2}$	26055.35	−73.84
$3d^6\,(^3D)\,4s$	$b\,^4D$	$1\frac{1}{2}$	31364.31	
		$\frac{1}{2}$	31368.30	
		$2\frac{1}{2}$	31387.82	
		$3\frac{1}{2}$	31483.10	
$3d^6\,(^5D)\,4p$	$z\,^6D^\circ$	$4\frac{1}{2}$	*38458.88*	
		$3\frac{1}{2}$	*38659.93*	−201.05
		$2\frac{1}{2}$	*38858.84*	−198.91
		$1\frac{1}{2}$	*39013.03*	−154.19
		$\frac{1}{2}$	*39109.13*	−96.10
$3d^6\,(^5D)\,4p$	$z\,^6F^\circ$	$5\frac{1}{2}$	*41968.05*	
		$4\frac{1}{2}$	*42114.83*	−146.78
		$3\frac{1}{2}$	*42237.00*	−122.17
		$2\frac{1}{2}$	*42334.62*	−97.62
		$1\frac{1}{2}$	*42401.20*	−66.58
		$\frac{1}{2}$	*42439.71*	−38.51
$3d^6\,(^5D)\,4p$	$z\,^6P^\circ$	$3\frac{1}{2}$	*42658.26*	
		$2\frac{1}{2}$	*43238.52*	−580.26
		$1\frac{1}{2}$	*43620.98*	−382.46
$3d^6\,(^5D)\,4p$	$z\,^4F^\circ$	$4\frac{1}{2}$	*44232.52*	
		$3\frac{1}{2}$	*44753.72*	−521.20
		$2\frac{1}{2}$	*45079.77*	−326.05
		$1\frac{1}{2}$	*45289.76*	−209.99
$3d^6\,(^5D)\,4p$	$z\,^4D^\circ$	$3\frac{1}{2}$	*44446.81*	
		$2\frac{1}{2}$	*44784.62*	−337.81
		$1\frac{1}{2}$	*45044.15*	−259.53
		$\frac{1}{2}$	*45206.38*	−162.23

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^6\,(^5D)\,4p$	$z\ ^4P^\circ$	$2\frac{1}{2}$	*46967.29*	
				−422.34
		$1\frac{1}{2}$	*47389.63*	
				−236.29
		$\frac{1}{2}$	*47625.92*	
—	$y\ ^4F^\circ$	$4\frac{1}{2}$	*65695.28*	
				−681.63
		$3\frac{1}{2}$	*66376.91*	
				−453.41
		$2\frac{1}{2}$	*66830.32*	
				−234.54
		$1\frac{1}{2}$	*67064.86*	

Fe V

$Z = 26$

22 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ {}^5D_0$

One multipled of *Fe V* has been located by White.

Reference

H. E. White, *Phys. Rev.* **33**, 914 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\ ({}^4F)\ 4s$	${}^5F$	1	0	
				284
		2	284	
				427
		3	711	
				573
		4	1284	
				669
		5	1953	
$3d^3\ ({}^4F)\ 4p$	${}^5G^\circ$	2	*68375*	
				585
		3	*68960*	
				775
		4	*69735*	
				971
		5	*70706*	
				1152
		6	*71858*	

Ga I $\qquad Z = 31$

31 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p\ ^2P^\circ_{\frac{1}{2}}$

First ionization potential = 5.97 volts

A part of this classification is given in Fowler and Paschen-Götze.

References

H. S. Uhler and J. W. Tanch, *Astrophys. Journ.* **55**, 291 (1922).
R. A. Sawyer and R. J. Lang, *Phys. Rev.* **34**, 718 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\, 4p$	$^2P^\circ$	$\frac{1}{2}$	*48379.8*	826.0
		$1\frac{1}{2}$	*47553.8*	
$5s$	^2S	$\frac{1}{2}$	23591.5	
$4d$	^2D	$1\frac{1}{2}$	13598.3	5.9
		$2\frac{1}{2}$	13592.4	
$6s$	^2S	$\frac{1}{2}$	10795.0	
$4s\, 4p^2$	^4P	$\frac{1}{2}$	10408	366
		$1\frac{1}{2}$	10042	575
		$2\frac{1}{2}$	9467	
$4s\, 4p^2$	^2S	$\frac{1}{2}$	8115	
$^2\, 6p$	$^2P^\circ$	$\frac{1}{2}$	*8004.3*	41.1
		$1\frac{1}{2}$	*7963.2*	
$5d$	^2D	$1\frac{1}{2}$	7577.1	8.4
		$2\frac{1}{2}$	7568.7	
$7s$	^2S	$\frac{1}{2}$	6222.0	
$7p$	$^2P^\circ$	$\frac{1}{2}$	*4939.3*	20.9
		$1\frac{1}{2}$	*4918.4*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	4806.2 4801.3	54.9
$8s$	^2S	$\frac{1}{2}$	4848.6	
$7d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	3305.0	
$9s$	^2S	$\frac{1}{2}$	2849	
$8d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	2354	

Ga II $\qquad Z = 31$

30 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\ {}^1S_0$

First ionization potential = 20.43 volts

This classification is given by Sawyer and Lang. The absolute values are given with respect to $3d^{10}\, 4s\ {}^2S_{\frac{1}{2}}$ of Ga III.

Reference

R. A. Sawyer and R. J. Lang, *Phys. Rev.* **34**, 712 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2$	${}^1S$	0	165458	
$4s\,4p$	${}^3P^\circ$	0	*118088*	446
		1	*117642*	934
		2	*116708*	
$4s\,4p$	${}^1P^\circ$	1	*94758*	
$4s\,5s$	${}^3S$	1	62515	
$4s\,5s$	${}^1S$	0	58802	
$4s\,4d$	${}^1D$	2	57739	
$4s\,4d$	${}^3D$	1	51642	25
		2	51617	34
		3	51583	
$4p^2$	${}^3P$	0	50757	524
		1	50233	912
		2	49321	
$4s\,5p$	${}^3P^\circ$	0	*47031*	89
		1	*46942*	210
		2	*46732*	
$4s\,5p$	${}^1P^\circ$	1	*44918*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s\ 6s$	^3S	1	32446	
$4s\ 5d$	^3D	1 2 3	28304 28292 28275	12 17
$4s\ 4f$	$^3F^\circ$	2, 3, 4	*28125*	
$4s\ 4f$	$^1F^\circ$	3	*28115*	
$4s\ 6d$	^1D	2	25764	
$4s\ 7s$	^3S	1	19965	
$4s\ 7s$	^1S	0	19445	
$4s\ 5f$	$^3F^\circ$	2, 3, 4	*17975*	
$4s\ 5f$	$^1F^\circ$	3	*17966*	
$4s\ 6d$	^3D	1 2 3	17942 17934 17925	8 9
$4s\ 7d$	^1D	2	17021	
$4s\ 7p$	$^1P_1^\circ$	1	*16626*	
$4s\ 6f$	$^3F^\circ$	2, 3, 4	*12458*	
$4s\ 7d$	^3D	1	12397	
$4s\ 8s$	^3S	1	13539	
$4s\ 8s$	^1S	0	13265	

Ga III $\qquad Z = 31$

29 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s\ ^2S_{\frac{1}{2}}$

Ionization potential = 30.6 volts

These terms have been taken from a paper by Rao. The lowest state is estimated to be 247800 cm.$^{-1}$.

References

K. R. RAO, *Proc. London Phys. Soc.* **39,** 150 (1927).
R. J. LANG, *Phys. Rev.* **30,** 762 (1927).
K. R. RAO, A. L. NARAYAN, and A. S. RAO, *Indian Journ. Phys.* **2,** 483 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s$	^2S	$\frac{1}{2}$	0	
$4p$	$^2P°$	$\frac{1}{2}$	*65161*	1713
		$1\frac{1}{2}$	*66874*	
$5s$	^2S	$\frac{1}{2}$	140733	
$4d$	^2D	$1\frac{1}{2}$	144076	112
		$2\frac{1}{2}$	144188	
$5p$	$^2P°$	$\frac{1}{2}$	*160751*	539 *157475* 523 (Lang)
		$1\frac{1}{2}$	*161290*	*157998*
$4f$	$^2F°$	$2\frac{1}{2}$	*185421*	6
		$3\frac{1}{2}$	*185427*	
$6s$	^2S	$\frac{1}{2}$	187552	
$5d$	^2D	$1\frac{1}{2}$	189173	63
		$2\frac{1}{2}$	189236	
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	208242	

Ga IV $Z = 31$

28 electrons $1s^2\,2s^2\,3s^2\,3p^6\,3d^{10}\,{}^1S_0$

First ionization potential = 63.9 volts

This classification is taken from the work of Mack, Laporte, and Lang. The lowest state has been given a negative value, because its position is not known with accuracy. The absolute value of the lowest state is about 517000 cm.$^{-1}$ with respect to $3d^9\,{}^2D$ of Ga V.

Reference

J. E. Mack, O. Laporte, and R. J. Lang, *Phys. Rev.* **31**, 748 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^{10}$	^1S	0	−149298	
$3d^9\ 4s$	^3D	3	0	
				−1455
		2	1455	
				−2120
		1	3575	
$4s$	^1D	2	6512	
$3d^9\ 4p$	$^3P^\circ$	2	*74730*	
				−3081
		1	*77811*	
				−1820
		0	*79631*	
$4p$	$^3F^\circ$	3	*78172*	
		4	*79444*	
		2	*80530*	
$4p$	$^3D^\circ$	3	*83678*	
				−636
		2	*84314*	
				−3080
		1	*87394*	
$4p$	$^1F^\circ$	3	*85426*	
$4p$	$^1P^\circ$	1	*86801*	
$4p$	$^1D^\circ$	2	*87945*	

Ge I $Z = 32$

32 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^2\ {}^3P_0$

Ionization potential = 8.09 volts

The classification has been taken from Rao's paper. Some terms are marked as uncertain. The absolute value of the lowest term is given as 65558 cm.$^{-1}$ with respect to $4p\ {}^2P_{\frac{1}{2}}$ of Ge II.

References

C. W. Gartlein, *Phys. Rev.* **31,** 782 (1928).
K. R. Rao, *Proc. Roy. Soc.* **A124,** 465 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\,4p^2$	^3P	0	0	
		1	557.1	557.1
		2	1409.9	852.8
$4s^2\,4p^2$	^1D	2	7125.9	
$4s^2\,4p^2$	^1S	0	16367.1	
$4s^2\,4p\ 5s$	$^3P^\circ$	0	*37451.6*	
		1	*37701.2*	250.6
		2	*39117.7*	1415.5
$4s^2\,4p\ 5s$	$^1P^\circ$	1	*40020.3*	
$4s^2\,4p\ 4d$	$^1D^\circ$	2	*48479.7*	
$4s^2\,4p\ 4d$	$^3D^\circ$	2	*48881.9*	
		1	*48962.3*	
		3	*49144.1*	
$4s^2\,4p\ 4d$	$^3F^\circ$	2	*50068.7*	
		3	*50322.8*	254.1

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\,4p\;\;4d$	$^3P°$	2	*51437.4*	−267.2
		1	*51704.6*	−275.2
		0	*51979.8*	
$4p\;\;6s$	$^3P°$	1	*52148.2*	−22.1
		0	*52170.3*	
		2	*53910.5*	
$4p\;\;4d$?	$^1F°$	3	*52592.0*	
$4p\;\;4d$	$^1P°$	1	*52847.0*	
$4p\;\;6s$	$^1P°$	1	*54174.6*	
$4p\;\;5d$	$^3D°$	2	*55372.4*	−97.3
		1	*55469.7*	
		3	*55685.6*	
$4s\;\;4p^3$	$^1P°$	1	*55473.6*	
$4s^2\,4p\;\;5d$?	$^1D°$	2	*55717.6*	
$4s\;\;4p^3$?	$^3P°$	2	*56654.9*	−742.2
		1	*57397.1*	−278.0
		0	*57675.1*	
$4s^2\,4p\;\;5d$	$^3F°$	3	*56828.3*	
$4p\;\;7s$	$^3P°$	1	*56920.6*	−245.9
		0	*57166.5*	
		2	*58931.4*	
$4p\;\;5d$	$^3P°$	2	*57178.5*	−252.2
		1	*57430.7*	−265.4
		0	*75696.1*	
$4p\;\;5d$	$^1P°$	1	*58056.6*	
$4s\;\;4p^3$?	$^1D°$	2	*58091.3*	
$4s^2\,4p\;\;5d$?	$^1F°$	3	*58941.6*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\,4p\;7s$	$^1P^\circ$	1	*59113.7*	
—	1°	?	*59522.5*	
$4s\;4p^3$	$^3D^\circ$	3	*59655.1*	
		2	*59688.1*	−33.0
		1	*59724.7*	−36.6
$4s^2\,4p\;6d$?	$^1D^\circ$	2	*60885.2*	
$4p\;6d$	$^1P^\circ$	1	*61151.9*	
—	2°	?	*61250.9*	
$4p\;6d$?	$^1F^\circ$	3	*61266.8*	
$4p\;8s$	$^1P^\circ$	1	*61342.8*	

Ge II $\qquad Z = 32$

31 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p\ {}^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 15.9 volts

This classification is from the work of Lang. Rao and Narayan have found a term at 74699 cm.$^{-1}$ which they attribute to $4s\,4p^2\,{}^4P_1$, but only from 2 lines. The absolute value of the lowest state given by Rao and Narayan, is 128635 cm.$^{-1}$

References

R. J. Lang, *Proc. Nat. Acad. Sci.* **14**, 32 (1928); *Phys. Rev.* **34**, 697 (1929).
K. R. Rao and A. L. Narayan, *Proc. Roy. Soc.* **A119**, 607 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2\,4p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*0* *1768*	1768
$4s^2\,5s$	${}^2S$	$\frac{1}{2}$	62402	
$4s\ \ 4p^2$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	65013 65181	168
$4s^2\,5p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*79005* *79365*	360
$4s^2\,4d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	80834 81010	176
$4s\ \ 4p^2$	${}^2S$	$\frac{1}{2}$	86395	
$4s\ \ 4p^2$	${}^2P$	$\frac{1}{2}$ $1\frac{1}{2}$	91010 92117	1107
$4s^2\,6s$	${}^2S$	$\frac{1}{2}$	94780	
$4s^2\,5d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	100088 100130	42
$4s^2\,4f$	${}^2F^{\circ}$	$2\frac{1}{2}$, $3\frac{1}{2}$	*100315*	

Ge III $Z = 32$

30 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ {}^1S_0$

First ionization potential = 34.07

This classification has been taken from a paper by Lang. The lowest state is estimated at 276036 cm.$^{-1}$.

Reference

R. J. Lang, *Phys. Rev.* **34**, 697 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2$	^1S	0	0	
$4s\ 4p$	$^3P^\circ$	0	*61733*	
				763
		1	*62496*	
				1642
		2	*64138*	
$4p$	$^1P^\circ$	1	*91873*	
$4d$	^1D	2	144972	
$4p^2$	^3P	0	147691	
				953
		1	148644	
				1729
		2	150373	
$4p^2$	^1D	2	148776	
$4s\ 5s$	^3S	1	158576	
$4d$	^3D	1	162851	
				71
		2	162922	
				96
		3	163028	
$5s$	^1S	0	167450	
$5p$	$^3P^\circ$	0	*181871*	
				168
		1	*182039*	
				359
		2	*182498*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s\ 5p$	$^1P^\circ$	1	*184309*	
$4p\ 4d$	$^1D^\circ$	2	*197122*	
$4s\ 4f$	$^3F^\circ$	2	*210455*	
		3	*210473*	18
		4	*210536*	63
$4s\ 4f$	$^1F^\circ$	3	*210531*	
$4s\ 6s$	^3S	1	211149	
$4p\ 4d$	$^1P^\circ$	1	*212359*	
$4s\ 5d$	^3D	1	213133	
		2	213164	31
		3	213208	44
$4p\ 4d$	$^1F^\circ$	3	*213579*	
$4s\ 5g$?	^1G	4	234910 ?	
$5g$?	^3G	3, 4, 5	234928 ?	
$4d^2$	^1D	2	235908	

Ge IV $Z = 32$

29 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s\;{}^2S_{\frac{1}{2}}$

Ionization potential = 45.5 volts

The classification is given by Lang. The absolute value of the lowest state is about 368700 cm.$^{-1}$ with respect to $3d^{10}\,{}^1S_0$ of Ge V.

Reference

R. J. Lang, *Phys. Rev.* **34**, 697 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^{10}\,4s$	^2S	$\frac{1}{2}$	0	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*81316* *84103*	2788
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	190607 190861	254
$5s$	^2S	$\frac{1}{2}$	199269	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*226459* *227397*	938
$4f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*257496* *257501*	5
$3d^9\,4s^2$	^2D	$2\frac{1}{2}$ $1\frac{1}{2}$	259942 264445	−4503
$3d^{10}\,5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	266637 266717	80
$6s$	^2S	$\frac{1}{2}$	270058	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*283221* *283763*	542
$5g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	298379 ?	

Ge V $\qquad Z = 32$

28 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\;{}^1S_0$

First ionization potential approximately 90 volts

The classification is given by Mack, Laporte, and Lang. The lowest state has not been found. The absolute value of the $3d^9\,4s$ state is given as 503000 cm.$^{-1}$

Reference

J. E. Mack, O. Laporte, and R. J. Lang, *Phys. Rev.* **31**, 748 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9\,4s$	${}^3D$	3	0	
		2	1740	−1740
		1	4536	−2796
$4s$	${}^1D$	2	7716	
$3d^9\,4p$	${}^3P^\circ$	2	*89541*	
		1	*93624*	−4083
		0	*96111*	−2487
$4p$	${}^3F^\circ$	3	*93535*	
		4	*95648*	
		2	*96574*	
$4p$	${}^3D^\circ$	3	*100956*	
		2	*101318*	−362
		1	*105323*	−4005
$4p$	${}^1F^\circ$	3	*102961*	
$4p$	${}^1P^\circ$	1	*104024*	
$4p$	${}^1D^\circ$	2	*106080*	

H I $\qquad\qquad$ $Z = 1$

1 electron $\qquad\qquad$ $1s\ ^2S_{\frac{1}{2}}$

Ionization potential = 13.529 ± 0.005 volts.

The energy states of atomic systems consisting of a nucleus and a single electron are given by the following formula

$$\frac{E(n,l,j)}{hc} = \mu c^2\left[1 + \frac{\alpha^2 Z^2}{(n - j - \frac{1}{2} + \sqrt{(j+\frac{1}{2})^2 - \alpha^2 Z^2})^2}\right]^{-\frac{1}{2}} - \mu c^2.$$

$\frac{E}{hc}$ is the term value in cm.$^{-1}$

$$\alpha = \frac{2\pi e^2}{hc} = (7.284 \pm 0.006)\cdot 10^{-3}$$

the Sommerfeld fine-structure constant, and

$$\mu = \frac{Mm}{M+m},$$

the reduced mass, M being the mass of the nucleus, m the mass of the electron.

Each level is characterized by the quantum numbers n, l, and j. The quantum number j is the total angular momentum, the resultant of the orbital moment l and the spin moment s. The possible values are

$n = 1, 2,$ etc.
$l = 0, 1, 2,$ etc., to $n - 1$.
$j = l + \frac{1}{2}$, and $l - \frac{1}{2}$, but for $l = 0$, $j = \frac{1}{2}$ only.

It is of importance to note that the two levels with the same value of n and j have the same energy, even though their l values are different, namely $j + \frac{1}{2}$ and $j - \frac{1}{2}$.

For practical purposes one can use the first terms of the expansion of the above formula and obtains

$$\frac{E(n,l,j)}{hc} = \frac{RZ^2}{n^2\left(1+\frac{m}{M}\right)} + \frac{R\alpha^2 Z^4}{n^3\left(1+\frac{m}{M}\right)}\left\{\frac{3}{4n} - \frac{1}{j+\frac{1}{2}}\right\}.$$

The term with α^2 arises from electron spin and relativity corrections, and

$$R = \frac{2\pi^2 me^4}{h^3 c} = 109737.42 \pm 0.06 \text{ cm.}^{-1}$$

is the Rydberg constant.

For hydrogen,

$$R_H = \frac{R}{\left(1 + \frac{m}{M_H}\right)} = 109677.759 \pm 0.05 \text{ cm.}^{-1}$$

The term formula becomes for this case

$$\frac{E\ (n,l,j)}{hc} = \frac{109677.759 \pm 0.05}{n^2} + \frac{5.820 \pm 0.009}{n^3}\left(\frac{3}{4n} - \frac{1}{j + \frac{1}{2}}\right).$$

In hydrogen, special names are used for the series of lines according to the quantum number n of the final level.

Final level $n = 1$: Lyman series, far ultra-violet.
$n = 2$: Balmer series, visible and near ultra-violet.
$n = 3$: Paschen series, infra-red.
$n = 4$: Bracket series, far infra-red.
$n = 5$: Pfund series, far infra-red.

The term with α^2 causes the lines to possess a fine structure, which in the case of hydrogen could only be observed for the levels with $n = 2$ in the first few lines of the Balmer series.

References

Fowler, Paschen-Götze.
W. Grotrian, "Graphische Darstellung der Spektren," Berlin, Springer (1928).
F. S. Bracket, *Astrophys. Journ.* **56**, 154 (1922).
A. H. Poetker, *Phys. Rev.* **30**, 418 (1927). Extension of Bracket series.
A. H. Pfund, *Journ. Opt. Soc. Am.* **9**, 139 (1924).
G. Hansen, *Ann. d. Physik* **78**, 558 (1925). Fine structure.
W. V. Houston, *Astrophys. Journ.* **64**, 81 (1926). Fine structure.
N. A. Kent, L. B. Taylor, and H. Pearson, *Phys. Rev.* **30**, 266 (1927). Fine structure.

He I $Z = 2$

2 electrons $1s^2\ ^1S_0$

First ionization potential = 24.465 volts

The classification of this spectrum can be found in Fowler and in Paschen-Götze. The lowest state has been discovered more recently by Lyman. The fine structure of several low triplet states has been resolved and the separations are given in the last column.

Two types of tables are given, the first containing only the lowest terms, followed by the complete set of terms in series arrangement.

One intercombination line has been found by Lyman.

References

T. Lyman, *Astrophys. Journ.* **60,** 1 (1924).
W. V. Houston, *Phys. Rev.* **29,** 749 (1929).
P. G. Kruger, *Phys. Rev.* **36,** 855 (1930).
J. J. Hopfield, *Astrophys. Journ.* **72,** 133 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$1s^2$	^1S	0	198298	
$1s\ 2s$	^3S	1	38454.682	
$1s\ 2s$	^1S	0	32033.30	
$1s\ 2p$	$^3P^\circ$	2, 1, 0	*29223.87*	−0.071, −0.992
$1s\ 2p$	$^1P^\circ$	1	*27175.852*	
$1s\ 3s$	^3S	1	15073.92	
$1s\ 3s$	^1S	0	13445.92	
$1s\ 3p$	$^3P^\circ$	2, 1, 0	*12746.08*	−0.02, −0.27
$1s\ 3d$	^3D	3, 2, 1	12209.09	−0.06, −0.02

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$1s\,3d$	^1D	2	12205.78	
$1s\,3p$	$^1P^\circ$	1	*12101.38*	
$1s\,4s$	^3S	1	8012.54	
$1s\,4s$	^1S	0	7370.50	
$1s\,4p$	$^3P^\circ$	2, 1, 0	*7093.58*	
$1s\,4d$	^3D	3, 2, 1	6866.17	−0.03, −0.01
$1s\,4d$	^1D	2	6864.29	
$1s\,4f$	$^3F^\circ$	4, 3, 2	*6858.22*	
$1s\,4f$	$^1F^\circ$	3	*6857.76*	
$1s\,4p$	$^1P^\circ$	1	*6818.05*	

HELIUM I

SERIES

$1s^2\ ^1S_0$
198298

1s ms		
m	$^3S_1$	$^1S_0$
2	38454.682	32033.30
3	15073.92	13445.94
4	8012.54	7370.50
5	4963.67	4647.22
6	3374.54	3195.83
7	2442.37	2331.81
8	1849.21	1775.97
9	1448.63	1397.87
10	1165.24	1128.64
11	957.95	
12	801.31	780.74
13	680.02	655.22
14	583.87	
15	508.37	

1s mp		
m	$^3P°$	$^1P°$
2	*29223.87*	*27175.852*
3	*12746.08*	*12101.38*
4	*7093.58*	*6818.05*
5	*4509.93*	*4368.25*
6	*3117.79*	*3035.83*
7	*2283.28*	*2231.59*
8	*1743.92*	*1709.44*
9	*1375.32*	*1351.05*
10	*1112.37*	*1094.59*
11	*918.02*	*904.82*
12	*770.56*	*760.44*
13	*655.93*	*648.05*
14	*565.10*	*558.85*
15	*491.89*	*486.88*
16	*432.05*	*427.96*
17	*382.49*	*379.13*
18	*340.98*	*338.20*
19	*305.88*	*303.56*
20	*275.93*	*273.98*
21	*250.17*	
22	*227.85*	

1s md		
m	^3D	^1D
3	12209.09	12205.78
4	6866.17	6864.29
5	4393.52	4392.46
6	3050.63	3049.98
7	2241.00	2240.69
8	1715.58	1715.27
9	1355.37	1355.51
10	1097.70	1097.92
11	907.25	907.38
12	762.33	762.46
13	649.53	649.81
14	560.06	560.08
15	487.95	
16	428.59	
17	379.07	
18	338.25	
19	303.57	
20	273.59	
21	248.50	

1s mf		
m	$^3F°$	$^1F°$
4	*6858.22*	*6857.76*
5	*4389.00*	*4390.69*

He II $\qquad\qquad$ $Z = 2$

1 electron $\qquad\qquad$ $1s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 54.14 volts

For a more detailed discussion compare H I.

The term values of ionized helium are given by the following formula:

$$\frac{E(n, l, j)}{hc} = \frac{109722.403 \times 4}{n^2} + \frac{5.821 \times 16}{n^3}\left(\frac{3}{4n} - \frac{1}{j + \frac{1}{2}}\right)$$

Special names are used for the following series of lines:

Final level $n = 3$: Fowler series, visible and near ultra-violet.

$n = 4$: Pickering series. Near infra-red and visible (observed in star spectra by Pickering).

The series with the final level $n = 1$ and $n = 2$ are in the far and extreme ultra-violet and were observed by Lyman. They have no special names.

The fine structure has been investigated in great detail by Paschen, especially for the line λ 4685.8, which arises from the transition $n = 4$ to $n = 3$.

References

Paschen-Götze and Fowler.

W. Grotrian, "Graphische Darstellung der Spektren, Springer, Berlin, 1928.

F. Paschen, *Ann. d. Physik* **82,** 689 (1927). Fine structure. Discussed in detail in all books on the theory of spectra.

P. G. Kruger, *Phys. Rev.* **36,** 855 (1930).

72 electrons

$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,4f^{14}\,5s^2\,5p^6\,5d^2\,6s^2\;{}^3F_2$

Many regularities in the arc spectrum of hafnium have been found by Meggers and Scribner. Lines have been accounted for by transitions between 7 low levels and 56 higher levels. It has not been possible to assign electron configurations and arrange the levels into multiplets except for the low set which has been so arranged tentatively by them.

Reference

W. F. Meggers and B. F. Scribner, *Bur. Stand. Journ. Res.* **4**, 169 (1930).

Configuration	Symbol	J	Term value	
$5d^2\,6s^2$	1	2	0.00	^3F
	2	3	2356.60	^3F
	3	4	4567.58	^3F
	4	0	5521.64	^3P
	5	2	5638.55	^1D
	6	1	6572.50	^3P
	7	2	8983.70	^3P
—	1°	3	*17679.73*	
	2°	2	*18010.98*	
	3°	1	*18143.36*	
	4°	3	*18381.48*	
	5°	3	*19292.68*	
	6°	1	*19791.27*	
	7°	4	*20960.07*	
	8°	2	*21738.71*	
	9°	2	*22450.51*	
	10°	3	*23448.60*	
	11°	3	*23644.74*	
	12°	3	*24985.35*	
	13°	1	*25194.46*	
	14°	2	*25634.22*	
	15°	2	*26104.50*	
	16°	3	*26305.74*	
	17°	1	*26463.92*	
	18°	2	*27149.63*	
	19°	1	*27533.80*	
	20°	4	*27551.06*	

(*Concluded*)

Configuration	Symbol	J	Term value	
—	21°	3	27654.34	
	22°	1	28047.81	
	23°	2	28267.43	
	24°	3	28583.75	
	25°	1	28790.28	
	26°	4	29246.62	
	27°	2	29401.54	
	28°	2	29752.86	
	29°	3	29996.83	
	30°	4	30733.18	
	31°	3	31342.58	
	32°	2	31610.72	
	33°	4	31943.24	
	34°	2	32533.33	
	35°	2	33121.43	
	36°	3	33139.11	
	37°	2	33538.10	
	38°	4	33909.34	
	39°	3	33949.23	
	40°	3	33994.75	
	41°	2	34277.79	
	42°	1	34596.46	
	43°	4	34805.86	
	44°	2	34877.03	
	45°	2	34947.95	
	46°	3	35453.71	
	47°	4	36074.98	
	48°	3	36237.32	
	49°	3	36609.82	
	50°	2	36772.90	
	51°	4	36850.02	
	52°	2	37066.1	
	53°	3	37217.70	
	54°	2	38325.41	
	55°	3	38407.80	
	56°	4	38987.84	
	57°	3	39193.88	
	58°	2	39435.11	
	59°	2	40194.43	
	60°	2	40267.20	
	61°	1	40704.14	
	62°	3	40767.3	
	63°	3	42302.14	

Hf II $Z = 72$

71 electrons

These terms have been found by Meggers and Scribner. No assignment of electron configurations has been given.

Reference

W. F. Meggers and B. F. Scribner, *Journ. Opt. Soc. Am.* **17**, 83 (1928).

Symbol	J	Term value	Symbol	J	Term value
1	$1\frac{1}{2}$	0.0	22°	$2\frac{1}{2}$	*34942.4*
2	$2\frac{1}{2}$	3050.9	23°	$1\frac{1}{2}$	*36373.4*
3	$1\frac{1}{2}$	3644.5	24°	$3\frac{1}{2}$	*36882.5*
4	$2\frac{1}{2}$	4904.9	25°	$1\frac{1}{2}$	*37886.0*
5	$3\frac{1}{2}$	6344.4	26°	$4\frac{1}{2}$	*38185.7*
6	$4\frac{1}{2}$	8361.8	27°	$3\frac{1}{2}$	*38498.5*
7	$2\frac{1}{2}$	12070.5	28°	$2\frac{1}{2}$	*38578.7*
8	$1\frac{1}{2}$	12920.9	29°	$2\frac{1}{2}$	*40506.8*
9	$2\frac{1}{2}$	13485.5	30°	$3\frac{1}{2}$	*41407.0*
10	$\frac{1}{2}$	15254.3	31°	$2\frac{1}{2}$	*41761.3*
11	$2\frac{1}{2}$	17368.9	32°	$4\frac{1}{2}$	*42391.0*
12	$3\frac{1}{2}$	17389.1	33°	$1\frac{1}{2}$	*42518.2*
13	$3\frac{1}{2}$	17710.7	34°	$\frac{1}{2}$	*43044.3*
14	$1\frac{1}{2}$	17830.4	35°	$2\frac{1}{2}$	*43680.7*
15	$3\frac{1}{2}$	21637.8	36°	$2\frac{1}{2}$	*43900.6*
16	$4\frac{1}{2}$	23145.7	37°	$3\frac{1}{2}$	*44400.0*
			38°	$3\frac{1}{2}$	*44690.8*
17°	$2\frac{1}{2}$	*29405.2*	39°	$2\frac{1}{2}$	*46674.5*
18°	$1\frac{1}{2}$	*31784.3*	40°	$3\frac{1}{2}$	*47157.7*
19°	$\frac{1}{2}$	*33136.3*	41°	$4\frac{1}{2}$	*47424.0*
20°	$2\frac{1}{2}$	*33181.0*	42°	$4\frac{1}{2}$	*48930.8*
21°	$2\frac{1}{2}$	*34355.1*	43°	$2\frac{1}{2}$	*49005.9*

80 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ {}^1S_0$

Ionization potential = 10.38 volts

The main part of this classification can be found in Paschen-Götze and Fowler. The first table gives the low states only, the other tables contain all terms.

Interesting new terms are the $x\ {}^3P^\circ$ at 16300, and the negative $6p^2\ {}^3P$ terms at −8000.

References

F. Paschen, *Ann. d. Physik* **6**, 47 (1930).
T. Takamine and T. Suga, *Inst. Phys. and Chem., Tokio, Sci. Papers* **13**, 1 (1930).
E. D. McAllister, *Phys. Rev.* **35**, 1585 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s^2$	^1S	0	84178.5	
$6s\,6p$	$^3P^\circ$	0	*46536.2*	
				1767.3
		1	*44768.9*	
				4630.6
		2	*40138.3*	
$6s\,6p$	$^1P^\circ$	1	*30112.8*	
$6s\,7s$	^3S	1	21830.8	
$6s\,7s$	^1S	0	20253.1	
—	$x\ {}^3P^\circ$	0	*16756.2 ?*	
				493.6
		1	*16316.6 ?*	
				1022.1
		2	*15294.5*	
$6s\,7p$	$^3P^\circ$	0	*14664.6*	
				145.5
		1	*14519.1*	
				1515.6
		2	*12973.5*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s\,6d$	^1D	2	12848.3	
$6s\,6d$	^3D	1 2 3	12845.1 12785.0 12749.9	60.1 35.1
$6s\,7p$	$^1P^\circ$	1	*12886.1*	
$6s\,8s$	^3S	1	10219.9	
$6s\,8s$	^1S	0	9776.9	
$6s\,8p$	$^3P^\circ$	0 1 2	*7734.6* *7714.4* *7357.8*	20.2 56.6
$6s\,7d$	^1D	1	7117.5	
$6s\,7d$	^3D	1 2 3	7096.5 7073.2 7051.7	23.3 21.5
$6s\,5f$	$^1F^\circ$	3	*6939.1*	
$6s\,5f$	$^3F^\circ$	2 3 4	*6944.2* *6941.9* *6937.2*	2.3 4.7

$6p^2$	^3P	0 1 2	−7860 −9798 —	1938

SERIES

$6s^2\ ^1S_0$
84178.5

$6s\ ms$		
m	$^3S_1$	$^1S_0$
7	21830.8	20253.1
8	10219.9	9776.9
9	5964.7	5777.4
10	3912.8	3816.0
11	2765.0	
12	2057.5	
13	1590.3	
14	1265.6	
15	1030.7	
16	856	
17	725	
18	617	
19	—	
20	464	
21	410	

$6s\ mp$				
m	$^3P_0°$	$^3P_1°$	$^3P_2°$	$^1P_1°$
6	*46536.2*	*44768.9*	*40138.3*	*30112.8*
7	*14664.6*	*14519.1*	*12973.5*	*12886.1*
8	*7734.6*	*7714.4*	*7357.8*	*5368.2*
9	*4805.8*	*4768.7*	*4604.7*	*4217.3*
10	*3279.6*	*3264.7*	*3158.4*	*3027.0*
11	*2381.2*	*2373.6*	*2307.4*	*2237.7*
12		*1802.3*	*1759.3*	*1717.3*
13		*1415.3*	*1387.6*	*1355.2*
14		*1142.0*	*1120.1*	*1097.4*
15				*900.9*
16				*761.1*

$x\ ^3P_0°$	$x\ ^3P_1°$	$x\ ^3P_2°$
16756.2 ?	*16316.6 ?*	*15294.5*

6s md						
m	$^3D_1$	$^3D_2$	$^3D_3$	$^1D_2$	m	$^1D_2$
6	12845.1	12785.0	12749.9	12848.3	15	764
7	7096.5	7073.2	7051.7	7117.5	16	649
8	4502.7	4491.0	4478.7	4521.0	17	559
9	3110.2	3104.5	3096.3	3124.2	18	487
10	2279.4	2273.1	2269.5	2288.4	19	427
11	1739.4		1734.5	1746.1	20	—
12	1370.0		1366.4	1376.4	21	336
13	1108.4		1105.2	1111.8	22	301
14	915.2		911.7		23	269
					24	244

<table>
<tr><th colspan="5">6s mf</th></tr>
<tr><th>m</th><th>$^3F_4^\circ$</th><th>$^3F_3^\circ$</th><th>$^3F_2^\circ$</th><th>$^1F_3^\circ$</th></tr>
<tr><td>5</td><td>6937.2</td><td>6941.9</td><td>6944.2</td><td>6939.1</td></tr>
<tr><td>6</td><td colspan="2">4432.8</td><td>4435.2</td><td>4437.7</td></tr>
</table>

Hg II $Z = 80$

79 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 18.67 volts

This classification has been taken from the work of Paschen and of Naudé. Rasmussen has located the $5d^{10}\,6g\ {}^2G$ and Ricard has given a term at 550965 and another at 6724. The first table contains all terms and the second group gives the terms based on $d^{10}\ {}^1S_0$ in the series form. It is of interest to note that the $5d^{10}\ mf\ {}^2F$ terms are inverted.

References

F. Paschen, *Berlin. Akad., Sitzungsber.* **32**, 563 (1928).
S. M. Naudé, *Ann. d. Physik* **3**, 1 (1929).
E. Rasmussen, Naturwiss. **17**, 389 (1929).
R. Ricard, *Comptes Rendus* **192**, 618 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$ Remarks
$5d^{10}\,6s$	^2S	½	151280	
$5d^9\ 6s^2$	^2D	2½	115766	−15038
		1½	100728	
$5d^{10}\,6p$	$^2P^\circ$	½	*99795*	9322
		1½	*90672*	
$5d^9\ 6s\,6p$	1°	3½	*74356*	$^4F^\circ$
	2°	2½	*74239*	$^4P^\circ$
	3°	3½	*67069*	$^4D^\circ$
	4°	2½	*66447.4*	$^4F^\circ$
	5°	1½	*65105*	$^4P^\circ$
	6°	½	*60216*	$^4P^\circ$
	7°	1½	*57190*	$^4F^\circ$
$5d^{10}\,7s$	^2S	½	55566	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$ Remarks
—	$20°$	$1\frac{1}{2}$	*55096.5*	
$5d^9\ 6s\ 6p$	$8°$	$2\frac{1}{2}$	*54188*	^4D
	$9°$	$2\frac{1}{2}$	*50422*	^2F
	$10°$	$1\frac{1}{2}$	*48098*	^4D
	$11°$	$\frac{1}{2}$	*47410*	
$5d^{10}\ 6d$	^2D	$1\frac{1}{2}$	46297	560
		$2\frac{1}{2}$	45737	
$5d^9\ 6s\ 6p$	$12°$	$1\frac{1}{2}$	*45194*	
	$13°$	$\frac{1}{2}$	*44987*	
	$14°$	$\frac{1}{2}$	*44668*	^4D
	$15°$	$3\frac{1}{2}$	*44566*	^2F
$5d^{10}\ 7p$	$^2P°$	$\frac{1}{2}$	*42982*	3672
		$1\frac{1}{2}$	*39310*	
$5d^9\ 6s\ 6p$	$16°$	$1\frac{1}{2}$	*42091*	
$5d^9\ 6s\ 7s$	^4D	$3\frac{1}{2}$	40434	
		$2\frac{1}{2}$	35080	
		$1\frac{1}{2}$	33941	
		$\frac{1}{2}$	31833	
$5d^{10}\ 8s$	^2S	$\frac{1}{2}$	29864	
—	$21°$	$2\frac{1}{2}$	*29320*	
—	22	$1\frac{1}{2}$	29094	$4d^9\ 6s\ 7s\ ^2D_{1\frac{1}{2}}$
$5d^{10}\ 5f$	$^2F°$	$3\frac{1}{2}$	*28128*	−257
		$2\frac{1}{2}$	*27871*	
$5d^{10}\ 7d$	^2D	$1\frac{1}{2}$	25956	254
		$2\frac{1}{2}$	25702	
$5d^{10}\ 8p$	$^2P°$	$\frac{1}{2}$	*24338*	853
		$1\frac{1}{2}$	*23485*	
$5d^{10}\ 9s$	^2S	$\frac{1}{2}$	18721	
—	23	$3\frac{1}{2}$	18566	$5d^9\ 6s\ 6d\ ^4D$?

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$ Remarks
$5d^{10}\,6f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*18012.5* *17930*	−82.5
$5d^{10}\,6g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	17627	
$5d^{10}\,8d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	16718 16582	136
$5d^{10}\,9p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*15813* *15451*	362
—	24 25	$2\frac{1}{2}$ $2\frac{1}{2}$	15014 14569	$4d^9\,6s\,7s\,^2D$? $4d^9\,6s\,6d\,^4D$?
$5d^{10}\,10s$	^2S	$\frac{1}{2}$	12846	
$5d^{10}\,7f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*12487* *12468*	−19
$5d^{10}\,7g$	^2G	$4\frac{1}{2}$, $3\frac{1}{2}$	12237.6	
$5d^{10}\,9d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	11653 11585	68
$5d^{10}\,10p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*11152* *10951*	201
—	26	$1\frac{1}{2}$	11146	$4d^9\,6s\,6d\,^4D$?
$5d^{10}\,11s$	^2S	$\frac{1}{2}$	9365.5	
$5d^{10}\,8f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*9152.7* *9149.3*	−3.4
$5d^{10}\,8g$	^2G	$4\frac{1}{2}$, $3\frac{1}{2}$	8986.6	
$5d^{10}\,10d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	8620 8570.5	49.5
$5d^{10}\,11p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*8321* *8163*	158
$5d^{10}\,12s$	^2S	$\frac{1}{2}$	7130	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$ Remarks
$5d^{10}\,9f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*6991* *6990*	1
$5d^{10}\,9g$	^2G	$4\frac{1}{2}, 3\frac{1}{2}$	6878.3	
—	27	$2\frac{1}{2}$	6724	
$5d^{10}\,11d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	6626.8 6600.4	26.4
—	28	$\frac{1}{2}$	6370	$5d^9\,6s\,6d\,^4D$?
$5d^{10}\,10f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*5512*	
$5d^{10}\,10g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	5432.65	
$5d^{10}\,10h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*5431*	
$5d^{10}\,12d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	5254.4 5227	27.4
—	29	$2\frac{1}{2}$	4633	
$5d^{10}\,11g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	4399.6	
$5d^{10}\,11h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*4398*	
$5d^{10}\,13d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	4266 4245	21
$5d^{10}\,12g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	3635.0	
$5d^{10}\,15d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	2969	
$5d^{10}\,16d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	2537	
—	30	$2\frac{1}{2}$	−8019	

SERIES

$5d^{10}\ ms$	
m	$^2S_{\frac{1}{2}}$
6	151280
7	55566
8	29864
9	18721
10	12846
11	9365.5
12	7130

$5d^{10}\ mp$		
m	$^2P_{\frac{1}{2}}^{\circ}$	$^2P_{1\frac{1}{2}}^{\circ}$
6	*99795*	*90672*
7	*42982*	*39310*
8	*24338*	*23485*
9	*15813*	*15451*
10	*11152*	*10951*
11	*8321*	*8163*

$5d^{10}\ md$		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
6	46297	45737
7	25956	25702
8	16718	16582
9	11653	11585
10	8620	8570.5
11	6626.8	6600.4
12	5254.4	5227
13	4266	4245
14	—	
15	2969	
16	2537	

$5d^{10}\ mf$		
m	$^2F_{2\frac{1}{2}}^{\circ}$	$^2F_{3\frac{1}{2}}^{\circ}$
5	*27871*	*28128*
6	*17930*	*18012.5*
7	*12468*	*12487*
8	*9149*.3	*9152.7*
9	*6991*	*6990*
10		*5512*

$5d^{10}\ mg$	
m	$^2G_{3\frac{1}{2},\ 4\frac{1}{2}}$
5	—
6	17627
7	12237.6
8	8986.6
9	6878.3
10	5432.65
11	4399.6
13	3635.0

$5d^{10}\ mh$	
m	$^2H_{4\frac{1}{2},\ 5\frac{1}{2}}^{\circ}$
6	—
7	—
8	—
9	—
10	*5431*
11	*4398*

Note: In case the *g*- and *h*-orbits are supposed not to penetrate, their principal quantum numbers should be one less than given in these tables.

78 electrons

$1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 4f^{14}\, 5s^2\, 5p^6\, 5d^{10}\ {}^1S_0$

This classification has been given by McLennan, McLay, and Crawford. The lowest state has not been found.

References

J. C. McLennan, A. B. McLay, and F. M. Crawford, *Trans. Roy. Soc. Can.* **22,** 247 (1928).

J. E. Mack, *Phys. Rev.* **34,** 17 (1929).

Configuration	Symbol	J	Term value	
$5d^9\ ({}^2D_{2\frac{1}{2}})\ 6s$	1	3	0	${}^3D$
	2	2	3179	${}^3D$
$({}^2D_{1\frac{1}{2}})\ 6s$	3	1	15556	${}^3D$
	4	2	18235	${}^1D$
$5d^9\ ({}^2D)\ 6p$	1°	2	*60699*	
	2°	3	*62777*	
	3°	4	*75143*	
	4°	1	*75756 ?*	
	5°	2	*75698*	
	6°	2	*78077*	
	7°	3	*78750*	
	8°	1	*83704*	
	9°	3	*89637 ?*	
	10°	2	*91736*	
	11°	1	*93636 ?*	

In I $\qquad\qquad$ $Z = 49$

49 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s^2\,5p\ {}^2P^\circ_{\frac{1}{2}}$

Ionization potential = 5.76 volts

This classification is given for the main part in Fowler and Paschen-Götze.

The first table contains only the lowest levels.

Reference

R. A. Sawyer and R. J. Lang, *Phys. Rev.* **34,** 718 (1929). $\quad 5s\,5p^2\ {}^4P$.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2\,5p$	${}^2P^\circ$	$\frac{1}{2}$	*46667.9*	2212.6
		$1\frac{1}{2}$	*44455.3*	
$6s$	${}^2S$	$\frac{1}{2}$	22294.8	
$5d$	${}^2D$	$1\frac{1}{2}$	13775.4	23.5
		$2\frac{1}{2}$	13751.9	
$5s\,5p^2$	${}^4P$	$\frac{1}{2}$	11697	1049
		$1\frac{1}{2}$	10648	1432
		$2\frac{1}{2}$	9216	
$5s^2\,7s$	${}^2S$	$\frac{1}{2}$	10366.0	
$7p$	${}^2P^\circ$	$\frac{1}{2}$	*7806.8*	111.3
		$1\frac{1}{2}$	*7695.5*	
$6d$	${}^2D$	$1\frac{1}{2}$	7619.5	49.9
		$2\frac{1}{2}$	7569.6	

INDIUM I

SERIES

$5s^2\,ms$	
m	$^2S_{\frac{1}{2}}$
6	22294.8
7	10366.0
8	6031.0
9	3949.5
10	2787.8
11	2068.8
12	1600
13	1226

$5s^2\,mp$		
m	$^2P_{\frac{1}{2}}^{\circ}$	$^2P_{1\frac{1}{2}}^{\circ}$
5	*46667.9*	*44455.3*
6	—	—
7	*7806.8*	*7695.5*
8	*4842.3*	*4785.7*
9	*3297.3*	*3266.9*
10	*2391.9*	*2370.1*
11	*1803.7*	

$5s^2\,md$		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
5	13775.4	13751.9
6	7619.5	7569.6
7	4831.8	4806.1
8	3328.3	3310.1
9	2443.6	2445.4
10	1855	(Unres.)
11	1456	
12	1174	
13	966	
14	809	

In II $\qquad Z = 49$

48 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\ {}^1S_0$

Ionization potential = 18.81 volts

These terms are from material kindly given to us by Sawyer and Lang.

References

J. B. Green and R. A. Loring, *Phys. Rev.* **30**, 574 (1927).
R. J. Lang, *Phys. Rev.* **30**, 762 (1927).
K. R. Rao, *Proc. London Phys. Soc.* **39**, 161 (1927)
R. A. Sawyer and R. J. Lang, unpublished data.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	^1S	0	152213	
$5s\ 5p$	$^3P°$	0 1 2	*109938* *108864* *106386*	1074 2478
$5s\ 5p$	$^1P°$	1	*89177*	
$5s\ 6s$	^3S	1	58294	
$5s\ 6s$	^1S	0	55187	
$5s\ 5d$	^1D	2	54584	
$5p^2$	^3P	0 1 2	50608 48966 46651	1642 2315
$5s\ 5d$	^3D	1 2 3	50126 50039 49907	87 132
$5s\ 5p$	$^3P°$	0 1 2	*44554* *44373* *43787*	181 586

INDIUM II

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\,6p$	$^1P^\circ$	1	*42453*	
$5s\,6d$	^1D	2	38335	
$5s\,7s$	^3S	1	30773	
$5s\,7s$	^1S	0	29714	
$5s\,4f$	$^3F^\circ$	2	*28571*	
		3	*28566*	5
		4	*28550*	16
$5s\,4f$	$^1F^\circ$	3	*28514*	
$5s\,7d$	^1D	2	27650	
$5s\,6d$	^3D	1	27473	
		2	27439	34
		3	27388	51
$5s\,7p$	$^1P^\circ$	1	*24624*	
$5s\,8s$	^3S	1	19139	
$5s\,8s$	^1S	0	18679	
$5s\,5f$	$^3F^\circ$	2	*18272*	
		3	*18266*	6
		4	*18253*	13
$5s\,5f$	$^1F^\circ$	3	*18227*	
$5s\,7d$	^3D	1	17491	
		2	17473	18
		3	17445	28
$5s\,8p$	$^1P^\circ$	1	*16118*	
$5s\,9s$	^3S	1	13099	
$5s\,9s$	^1S	0	12847	
$5s\,6f$	$^3F^\circ$	2	*12666*	
		3	*12662*	4
		4	*12649*	13

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\,6f$	$^1F^\circ$	3	*12629*	
$5s\,8d$	^3D	1 2 3	12134 12120 12103	14 17
$5s\,9p$	$^1P^\circ$	1	*11386*	
$5s\,10s$	^3S	1	9520	
$5s\,7f$	$^3F^\circ$	2 3 4	*9200* *9168* *9153*	32 15
$5s\,9d$	^3D	1	8925	
$5s\,10p$	$^1P^\circ$	1	*8500*	
$5s\,11s$	^3S	1	7238	
$5s\,10d$	^3D	1	6833	
$5s\,11p$	$^1P^\circ$	1	*6565*	
$5s\,12s$	^3S	1	5688	
$5s\,11d$	^3D	1	5418	
$5s\,12p$	$^1P^\circ$	1	*5215*	
$5s\,13s$	^3S	1	4594	
$5s\,12d$	^3D	1	4395	
$5s\,14s$	^3S	1	3785	
$5s\,13d$	^3D	1	3622	

47 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s\ ^2S_{\frac{1}{2}}$

Ionization potential = 27.9 volts

This classification is taken from the work of Lang and of Rao, Narayan, and Rao.

The absolute value of the lowest state is 226,133 cm.$^{-1}$.

References

R. J. Lang, *Proc. Nat. Acad. Sci.* **13,** 341 (1927); **15,** 414 (1929).
K. R. Rao, A. L. Narayan, and A. S. Rao, *Indian Journ. Phys.* **2,** 482 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s$	^2S	$\frac{1}{2}$	0	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*57185* *61527*	4342
$6s$	^2S	$\frac{1}{2}$	126878	
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	128458 128748	290
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*144588* *145925*	1337
$4f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*161979*	
$7s$	^2S	$\frac{1}{2}$	169427	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	170531 170713	182
$5f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*185813 ?*	
$5g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	186533	

In IV $\quad Z = 49$

46 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\ {}^1S_0$

Ionization potential about 43 volts

This classification has been given by Gibbs and White. The absolute value of the lowest state is about 350,000 cm.$^{-1}$.

Reference

R. C. Gibbs and H. E. White, *Phys. Rev.* **31,** 776 (1928).

Configuration	Symbol	J	Term value	
$4d^{10}$	${}^1S$	0	0	
$4d^9\ ({}^2D_{2\frac{1}{2}})\ 5s$	1	3	138785	${}^3D$
	2	2	130981	${}^3D$
$({}^2D_{1\frac{1}{2}})\ 5s$	3	1	135893	${}^3D$
	4	2	138764	${}^1D$
$4d^9\ ({}^2D)\ 5p$	1°	2	*194004*	${}^3P$
	2°	3	*196706*	${}^3F$
	3°	1	*200662*	${}^3P$
	4°	4	*201158*	${}^3F$
	5°	2	*202129*	${}^3D$
	6°	0	*205057*	${}^3P$
	7°	2	*205357*	${}^3F$
	8°	3	*205953*	${}^3D$
	9°	1	*208702*	${}^1P$
	10°	3	*209886*	${}^1F$
	11°	1	*211650*	${}^3D$
	12°	2	*212785*	${}^1D$

77 electrons

$1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 4f^{14}\, 5s^2\, 5p^6\, 5d^9\ {}^2D_{2\frac{1}{2}}$

These even terms were published by Meggers and Laporte. The two lowest ones are probably $5d^9\ {}^2D$.

Reference

W. F. MEGGERS and O. LAPORTE, *Phys. Rev.* **28**, 642 (1926).

Symbol	J	Term value	$\Delta\nu$	
1	$2\frac{1}{2}$	0.0	−2835.0	^2D ?
2	$1\frac{1}{2}$	2835.0		^2D ?
3		5785.0		
4		6324.3		
5		7107.2		
6		9878.1		
7		11831.7		
8		12219.1		
9		12952.3		
10		13088.6		
11		16104.0		
12		19061.5		

K I $\qquad Z = 19$

19 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 4s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 4.32 volts

Nothing has been added since Paschen-Götze and Fowler.

Two types of tables are given: the first, containing only the lowest terms, the second containing the complete set of terms in series arrangement.

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s$	^2S	$\frac{1}{2}$	35005.88	
$4p$	$^2P°$	$\frac{1}{2}$ $1\frac{1}{2}$	*22020.77* *21963.06*	57.71
$5s$	^2S	$\frac{1}{2}$	13980.28	
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	13470.26 13467.52	2.74
$5p$	$^2P°$	$\frac{1}{2}$ $1\frac{1}{2}$	*10304.39* *10285.70*	19.69
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	7608.3	
$6s$	^2S	$\frac{1}{2}$	7555.69	
$4f$	$^2F°$	$2\frac{1}{2}, 3\frac{1}{2}$	*6878.5*	

SERIES

mp		
m	$^2P_{\frac{1}{2}}°$	$^2P_{1\frac{1}{2}}°$
4	*22020.77*	*21963.06*
5	*10304.39*	*10285.70*
6	*6009.33*	*6001.18*
7	*3934.83*	*3930.00*
8	*2780.56*	*2778.27*

SERIES (*Concluded*)

mp			
m	$^2P_{\frac{1}{2},\,1\frac{1}{2}}^{\circ}$	m	$^2P_{\frac{1}{2},\,1\frac{1}{2}}^{\circ}$
9	*2064.6*	18	*409.2*
10	*1595.5*	19	*363.5*
11	*1268.8*	20	*327.5*
12	*1033.4*	21	*296.2*
13	*861.7*	22	*267.3*
14	*728.2*	23	*241.9*
15	*622.1*	24	*221.3*
16	*536.8*	25	*202.0*
17	*467.8*	26	*185.0*
		27	*171.7*

ms	
m	$^2S_{\frac{1}{2}}$
4	35005.88
5	13980.28
6	7555.69
7	4732.83
8	3240.44
9	2357.51
10	1791.49
11	1407.7
12	1136.2
13	936.6

md	
m	$^2D_{1\frac{1}{2},\,2\frac{1}{2}}$
3	13470.26 ($1\frac{1}{2}$) 13467.52 ($2\frac{1}{2}$)
4	7608.3
5	4821.89
6	3309.81
7	2407.42
8	1827.76
9	1433.57
10	1156.3
11	955.9

mf	
m	$^2F_{2\frac{1}{2},\,3\frac{1}{2}}^{\circ}$
4	*6878.5*
5	*4404.2*
6	*3056.5*
7	*2244.3*
8	*1714.8*

K II $Z = 19$

18 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\ {}^1S_0$

First ionization potential = 31.7 volts

These terms of K II are taken from the work of Bowen who has arranged the previous work of de Bruin and added the low ${}^1S$ state. For the notation compare Ne I.

The absolute value of the lowest state has been given as 256637 cm.$^{-1}$ with respect to $3p^5\ {}^2P_{1\frac{1}{2}}$ of K III.

References

T. L. de Bruin, *Zeits. f. Physik* **38**, 94 (1926).
I. S. Bowen, *Phys. Rev.* **31**, 497 (1928).

	Configuration	Symbol	J	Term value	
—	$3p^6$	${}^1S$	0	0	
$1s_5$	$3p^5\ ({}^2P_{1\frac{1}{2}})4s$	1°	2	*162507.0*	(${}^3P_2$)
$1s_4$		2°	1	*163237.0*	(${}^3P_1$)
$1s_3$	$({}^2P_{\frac{1}{2}})\ 4s$	3°	0	*165149.5*	(${}^3P_0$)
$1s_2$		4°	1	*166461.5*	(${}^1P_1$)
$3d_6$	$({}^2P_{1\frac{1}{2}})\ 3d$	1°	0	*163436.3*	
$3d_5$		2°	1	*164496.1*	
$3d_3$		3°	2	*164932.3*	
$3d_4'$		4°	4	—	
$3d_4$		5°	3	*170835.4*	
$3d_1''$		6°	2	*171526.8*	
$3d_1'$		7°	3	—	
$3d_2$		8°	1	—	
$2p_{10}$	$({}^2P_{1\frac{1}{2}})\ 4p$	1	1	183208.4	
$2p_9$		2	3	186388.5	
$2p_8$		3	2	186685.6	
$2p_7$		4	1	187531.1	
$2p_6$		5	2	188154.4	
$2p_5$		6	0	189772.0	

(Concluded)

	Configuration	Symbol	J	Term value	
$2p_4$	$3p^5$ ($^2P_{\frac{1}{2}}$) $4p$	7	1	189243.7	
$2p_3$		8	2	189661.7	
$2p_2$		9	1	190134.8	
$2p_1$		10	0	194776.1	
$2s_5$	($^2P_{1\frac{1}{2}}$) $5s$	1°	2	*212575.5*	($^3P_2$)
$2s_4$		2°	1	*212992.9*	($^3P_1$)
$2s_3$	($^2P_{\frac{1}{2}}$) $5s$	3°	0	*214726.0*	($^3P_0$)
$2s_2$		4°	1	*215018.8*	($^1P_1$)
$4d_6$	($^2P_{1\frac{1}{2}}$) $4d$	1°	0	—	
$4d_5$		2°	1	*215404.9*	
$4d_3$		3°	2	*215855.8*	
?		7°	—	*217066.3*	
$4d_4$		5°	3	*217726.4*	
$4d_1''$		6°	2	*219196.2*	
?		8°	—	*223124.1*	

K III $\qquad$ $Z = 19$

17 electrons $\qquad$ $1s^2\,2s^2\,2p^6\,3s^2\,3p^5\ {}^2P_{1\frac{1}{2}}^{\circ}$

First ionization potential = 47 volts

These terms are taken from a paper by De Bruin. All states from the $3p^4\ ({}^3P)\ 4p$ and $3p^4\ ({}^3P)\ 4s$ configuration are found.

The absolute value of the lowest state has been estimated to be about 377000 cm.$^{-1}$ with respect to $3p^4\ {}^3P$ of K IV.

References

T. L. de Bruin, *Zeits. f. Physik* **53**, 658 (1929).
I. S. Bowen, *Phys. Rev.* **31**, 497 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^5$	${}^2P^{\circ}$	$1\frac{1}{2}$	*0*	−2164
		$\frac{1}{2}$	*2164*	
$3s\,3p^6$	${}^2S$	$\frac{1}{2}$	130609	
$3s^2\,3p^4\,({}^3P)\,4s$	${}^4P$	$2\frac{1}{2}$	206755.9	−1265.9
		$1\frac{1}{2}$	208021.8	−773.5
		$\frac{1}{2}$	208795.3	
$4s$	${}^2P$	$1\frac{1}{2}$	212727.1	−1506.9
		$\frac{1}{2}$	214234.0	
$4p$	${}^4P^{\circ}$	$2\frac{1}{2}$	*236846.0*	−400.2
		$1\frac{1}{2}$	*237246.2*	−542.9
		$\frac{1}{2}$	*237789.1*	
$4p$	${}^4D^{\circ}$	$3\frac{1}{2}$	*240163.9*	−613.6
		$2\frac{1}{2}$	*270777.5*	−721.8
		$1\frac{1}{2}$	*241499.3*	−361.4
		$\frac{1}{2}$	*241860.7*	
$4p$	${}^2D^{\circ}$	$2\frac{1}{2}$	*242454.6*	−995.3
		$1\frac{1}{2}$	*243449.9*	
$4p$	${}^2P^{\circ}$	$1\frac{1}{2}$	*243949.1*	−1434.9
		$\frac{1}{2}$	*245384.0*	
$4p$	${}^4S^{\circ}$	$1\frac{1}{2}$	*245959.6*	

K IV $\quad Z = 19$

16 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4\ {}^3P_2$

In this spectrum a ${}^3P - {}^3P^\circ$ group has been found by Bowen.

Reference

I. S. Bowen, *Phys. Rev.* **31**, 497 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p^4$	${}^3P$	2	0	
				−1675
		1	1675	
				−650
		0	2325	
$3s\ 3p^5$	${}^3P^\circ$	2	*134181*	
				−1477
		1	*135658*	
				−799
		0	*136457*	

Kr I $\qquad Z = 36$

36 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\ {}^1S_0$

First ionization potential = 13.940 volts

This spectrum has been analyzed by Meggers, De Bruin, and Humphreys. The absolute values of all terms are given with respect to $4p^5\ {}^2P_{1\frac{1}{2}}$ of Kr II. The first table gives only the low states.

References

W. Gremmer, *Zeits. f. Physik* **54**, 215 (1929).

W. F. Meggers, T. L. de Bruin, and C. J. Humphreys, *Bur. Stand. Journ. Res.* **3**, 129 (1929).

Paschen notation	Configuration	Symbol	J	Term value	
$1p_0$	$4p^6$	^1S	0	112914.50	
$1s_5$	$4p^5\ ({}^2P_{1\frac{1}{2}})\ 5s$	1°	2	*32943.47*	$^3P_2{}^\circ$
$1s_4$		2°	1	*31998.47*	$^3P_1{}^\circ$
$1s_3$	$4p^5\ ({}^2P_{\frac{1}{2}})\ 5s$	3°	0	*27723.57*	$^3P_0{}^\circ$
$1s_2$		4°	1	*27068.57*	$^1P_1{}^\circ$
$2p_{10}$	$4p^5\ ({}^2P_{1\frac{1}{2}})\ 5p$	1	1	21746.72	
$2p_9$		2	3	20620.87	
$2p_8$		3	2	20607.88	
$2p_7$		4	1	19950.80	
$2p_6$		5	2	19791.92	
$2p_5$		6	0	18822.34	
$2p_4$	$4p^5\ ({}^2P_{\frac{1}{2}})\ 5p$	7	1	15319.27	
$2p_3$		8	1	14996.09	
$2p_2$		9	2	14970.09	
$2p_1$		10	0	14060.20	
$3d_5$	$4p^5\ ({}^2P_{1\frac{1}{2}})\ 4d$	2°	1	*13267*	
$2s_5$	$4p^5\ ({}^2P_{1\frac{1}{2}})\ 6s$	1°	2		
$2s_4$		2°	1	*13023*	$^3P_1{}^\circ$

(*Concluded*)

Paschen notation	Configuration	Symbol	J	Term value	
$2s_3$	$4p^5\,(^2P_{\frac{1}{2}})\,6s$	$3°$	0		
$2s_2$		$4°$	1	*8027.90*	$^1P_1°$
$3p_{10}$	$4p^5\,(^2P_{1\frac{1}{2}})\,6p$	1	1	10028.00	
$3p_9$		2	3	9799.61	
$3p_8$		3	2	9793.94	
$3p_7$		4	1	9601.56	
$3p_6$		5	2	9552.56	
$3p_5$		6	0	9153.54	
$4d_1'$	$4p^5\,(^2P_{1\frac{1}{2}})\,5d$	$7°$	3	*9213.84*	
$4d_5$		$2°$	1	*9113.43*	
$4d_6$		$1°$	0	*8393.70*	
$4d_4'$		$3°$	4	*8298.27*	
$4d_4$		$5°$	3	*7998.83*	
$4d_3$		$4°$	2	*7907.97*	
$4d_1''$		$6°$	2	*7751.72*	
$4d_2$		$8°$	1	*7144.49*	

SERIES

$2p^6\ ^1S_0$
112914.50

m	$4p^5\,(^2P_{1\frac{1}{2}})\,ms$		$4p^5\,(^2P_{\frac{1}{2}})\,ms$	
	s_5 $1_2°$	s_4 $2_1°$	s_3 $3_0°$	s_2 $4_1°$
5	*32943.47*	*31998.47*	*27723.57*	*27068.57*
6		*13023*		*8027.90*
7		*7267.46*		
8		*4590.11*		
9		*3163.03*		
10		*2306.71*		

SERIES (*Concluded*)

$4p^5\ (^2P_{1\frac{1}{2}})\ mp$						
m	p_{10} 1_1	p_9 2_3	p_8 3_2	p_7 4_1	p_6 5_2	p_5 6_0
5	21746.72	20620.87	20607.88	19950.80	19791.92	18822.34
6	10028.00	9799.61	9793.94	9601.56	9552.56	9153.54
7	5909.65	5774.31	5774.45	5694.16	5668.85	5504.86
8	3832.18	3811.55	3809.29	3765.58	3753.99	3618.88
9		2706.30		2680.82	2672.43	2607.43

$4p^5\ (^2P_{\frac{1}{2}})\ mp$				
m	p_4 7_1	p_3 8_1	p_2 9_2	p_1 10_0
5	15319.27	14996.09	14970.09	14060.20
6	4476.80	4400.84	4347.34	4098.69

$4p^5\ (^2P_{1\frac{1}{2}})\ md$								
m	d_6 $1_0°$	d_5 $2_1°$	d_4' $3_4°$	d_3 $4_2°$	d_4 $5_3°$	d_1'' $6_2°$	d_1' $7_3°$	d_2 $8_1°$
4	—	*13267*	—	—	—	—	—	—
5	*8393.70*	*9113.43*	*8298.27*	*7907.97*	*7998.83*	*7751.72*	*9213.84*	*7144.49*
6	*5311.57*	*5238.90*	*5136.37*	*5118.27*	*5038.30*	*4922.37*	*4868.83*	*4541.94*
7	*3584.02*	*3572.26*	*3481.30*	*3539.84*	*3443.72*	*3387.57*	*3336.02*	*3135.82*
8	*2624.77*	*2579.47*	*2511.42*	*2402.10*	*2444.62*	*2418.41*	*2406.97*	
9	*1981.07*	*1911.99*	*1896.22*		*1867.71*			
10			*1482.04*		*1464.47*			
11			*1189.81*					
12			*976.18*					

$4p^5\ (^2P_{1\frac{1}{2}})\ mf$		
m	X 1_1	Y 2_2
4	6950.21	6893.68
5	4434.40	4441.10
6	3078.40	

Kr II $Z = 36$

35 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^5\ {}^2P^\circ_{1\frac{1}{2}}$

First ionization potential = 26.4 volts (Kichlu)

The classification is taken from a paper by Kichlu. The assignments of several terms seem rather uncertain. The absolute value of the lowest state is estimated to be 214000 cm.$^{-1}$ with respect to $4p^4\ {}^3P$ of Kr III. This gives an ionization potential of 26.4 volts which does not agree with a previous measurement of 28.25 volts.

References

P. K. Kichlu, *Proc. Roy. Soc.* **A120,** 643 (1928).

C. J. Bakker and P. Zeeman, *Proc. Roy. Acad. Sci. Amsterdam* **32,** 565 (1929). Zeeman effect.

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^5$	${}^2P^\circ$	$1\frac{1}{2}$	*0*	
		$\frac{1}{2}$	*5371*	−5371
$4p^4\ ({}^3P)\ 5s$	${}^4P$	$2\frac{1}{2}$	112830	
		$1\frac{1}{2}$	115094	−2264
		$\frac{1}{2}$	117604	−2510
$4p^4\ ({}^3P)\ 5s$	${}^2P$	$1\frac{1}{2}$	118475	
		$\frac{1}{2}$	121003	−2528
$4p^4\ ({}^1D)\ 5s$?	${}^2D$	$2\frac{1}{2}$	120428	
		$1\frac{1}{2}$	121780	−1352
$4p^4\ ({}^1S)\ 5s$	${}^2S$	$\frac{1}{2}$	127591	
$4p^4\ ({}^3P)\ 5p$	${}^4P^\circ$?	$2\frac{1}{2}$	*133925.7*	
		$1\frac{1}{2}$	*134288.5*	−362.8
		$\frac{1}{2}$	*135173.3*	−884.8
$4p^4\ ({}^3P)\ 5p$?	${}^4S^\circ$?	$1\frac{1}{2}$	*135783.0*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^4\ (^3P)\ 5p$?	$^4D^\circ$?	$3\frac{1}{2}$	—	
		$2\frac{1}{2}$	*136070.9*	
		$1\frac{1}{2}$	*138381.5*	−2310.6
		$\frac{1}{2}$	*139103.5*	−722.0
$4p^4\ (^3P)\ 5p$?	$^2D^\circ$?	$2\frac{1}{2}$	*140119.1*	
		$1\frac{1}{2}$	*141722.7*	−1603.6
$4p^4\ (^3P)\ 5p$?	$^2P^\circ$?	$1\frac{1}{2}$	*140137.2*	
		$\frac{1}{2}$	*141995.7*	−1858.5
$4p^4\ (^3P)\ 5p$?	$^2S^\circ$?	$\frac{1}{2}$	*142363.6*	
$4p^4\ 5d$?	1	3	157079.2	
or	2	3	157885.3	
$4p^4\ 6s$?	3	3	161285.1	
	4	3	161409.4	
	5	3	161451.9	
	6	2	161802.0	
	7	2	161877.5	
	8	2	162059.3	
	9	2	162556.3	
	10	3	163358.4	
	11	2	164439.7	
	12	3	165077.6	
	13	3	165141.9	
	14	1	167001.6	
	15	2	167519.1	
	16	2	167913.2	
	17	1	169705.0	
—	18°	1	*174589.0*	
	19°	1	*176626.6*	

Kr III $\qquad Z = 36$

34 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^4\ {}^3P_2$

This classification is given by Deb and Dutt.

Reference

S. C. Deb and A. K. Dutt, *Zeits. f. Physik* **67**, 138 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^3\,5s$	${}^5S^\circ$	2	*0*	
$4d$	${}^5D^\circ$	4	*1794*	
				−173
		3	*1967*	
				−123
		2	*2084*	
				−59
		1	*2143*	
				−74
		0	*2217*	
$5p$	${}^5P$	1	30423	
				162
		2	30585	
				274
		3	30859	
$6s$	${}^5S^\circ$	2	*65919*	
$5d$	${}^5D^\circ$	0	—	
		1	*67890*	
				52
		2	*67942*	
				75
		3	*68017*	
				126
		4	*68143*	

57 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ 5d\ 6s^2\ {}^2D_{1\frac{1}{2}}$

These terms have been given by Meggers. The division into multiplets and the assignment of electron configurations are uncertain except for the two lowest multiplets.

References

W. F. Meggers, *Journ. Wash. Acad. Sci.* **17**, 25 (1927).
W. F. Meggers and K. Burns, *Journ. Opt. Soc. Am.* **14**, 449 (1927). Hyperfine structure.
H. E. White, *Phys. Rev.* **34**, 1404 (1929). Probable nuclear moment $I = 2\frac{1}{2}$.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d\ 6s^2$	^2D	$1\frac{1}{2}$	0.0	
				1053.2
		$2\frac{1}{2}$	1053.2	
$5d^2\ (^3F)\ 6s$	^4F	$1\frac{1}{2}$	2668.2	
				341.8
		$2\frac{1}{2}$	3010.0	
				484.6
		$3\frac{1}{2}$	3494.6	
				627.0
		$4\frac{1}{2}$	4121.6	
$5d\ 6s\ (^1D)\ 6p$	$^2D^\circ$?	$2\frac{1}{2}$	*14804.1*	
				−392.7
		$1\frac{1}{2}$	*15196.8*	
$5d\ 6s\ (^3D)\ 6p$	$^2D^\circ$	$1\frac{1}{2}$	*15031.7*	
				1506.7
		$2\frac{1}{2}$	*16538.4*	
$5d\ 6s\ (^3D)\ 6p$	$^2F^\circ$	$2\frac{1}{2}$	*16856.9*	
				1053.3
		$3\frac{1}{2}$	*17910.2*	
$5d^2\ 6p$?	$^2D^\circ$	$1\frac{1}{2}$	*17699.8*	
				247.3
		$2\frac{1}{2}$	*17947.1*	
$5d^2\ (^3F)\ 6p$	$^4G^\circ$	$2\frac{1}{2}$	*18156.9*	
				447.0
		$3\frac{1}{2}$	*18603.9*	
				525.4
		$4\frac{1}{2}$	*19129.3*	
				988.1
		$5\frac{1}{2}$	*20117.4*	

LANTHANUM I

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d^2\ (^1D)\ 6p$	$^2D^\circ$	$1\frac{1}{2}$	*18172.3*	
		$2\frac{1}{2}$	*19379.4*	1207.1
$5d\ 6s\ (^3D)\ 6p$	$^2P^\circ$	$1\frac{1}{2}$	*20019.1*	
		$\frac{1}{2}$	*20197.4*	178.3
$5d^2\ (^3F)\ 6p$	$^4F^\circ$	$1\frac{1}{2}$	*20083.0*	
		$2\frac{1}{2}$	*20338.2*	255.2
		$3\frac{1}{2}$	*20763.2*	425.0
		$4\frac{1}{2}$	*21384.0*	620.8
$5d^2\ (^1D)\ 6p$	$^2F^\circ$	$2\frac{1}{2}$	*20972.1*	
		$3\frac{1}{2}$	*21447.9*	475.8
—	1°		*21662.5*	
$5d^2\ (^3F)\ 6p$	$^4D^\circ$	$\frac{1}{2}$	*22246.6*	
		$1\frac{1}{2}$	*22439.4*	192.8
		$2\frac{1}{2}$	*22804.3*	364.9
		$3\frac{1}{2}$	*23303.2*	498.9
$5d^2\ (^3F)\ 6p$	$^2F^\circ$	$2\frac{1}{2}$	*23875.0*	
		$3\frac{1}{2}$	*24409.7*	534.7
—	$^4F^\circ$	$1\frac{1}{2}$	*24507.8*	
		$2\frac{1}{2}$	*24984.3*	476.5
		$3\frac{1}{2}$	*25380.3*	396.0
		$4\frac{1}{2}$	*25997.0*	616.7
	$^2F^\circ$	$3\frac{1}{2}$	*25218.1*	
		$2\frac{1}{2}$	*25643.0*	424.9
	2°		*27022.7*	
	$^2P^\circ$?	$\frac{1}{2}$	*27968.7*	
		$1\frac{1}{2}$	*28722.4*	753.7
	$^2D^\circ$?	$2\frac{1}{2}$	*29502.3*	
		$1\frac{1}{2}$	*29565.0*	−62.7
	3°	—	*30788.5*	
	4°	—	*30897.0*	

La II $\qquad Z = 57$

56 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\, 5p^6\, 5d^2\ {}^3F_2$

These terms of the lanthanum spark spectrum are from the unpublished material of Meggers, with assignment of electron configurations by Russell. There are many states which involve an electron excited to a $4f$ state.

References

W. F. Meggers, *Journ. Opt. Soc. Am.* **14**, 191 (1927).
W. F. Meggers and K. Burns, *Journ. Opt. Soc. Am.* **14**, 449 (1927).
W. F. Meggers, unpublished material.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d^2$	^3F	2	0.00	
		3	1016.10	1016.10
		4	1970.70	954.60
$5d\ 6s$	^1D	2	1394.46	
$5d\ 6s$	^3D	1	1895.15	
		2	2591.60	696.45
		3	3250.35	658.75
$5d^2$	^3P	0	5249.70	
		1	5718.12	468.42
		2	6227.42	509.30
$6s^2$	^1S	0	7394.57	
$5d^2$	^1G	4	7473.32	
$5d^2$	^1D	2	10094.86	
$4f\ 6s$	$^3F^\circ$	2	*14147.98*	
		3	*14375.17*	227.19
		4	*15698.74*	1323.57
$4f\ 6s$	$^1F^\circ$	3	*15773.77*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4f\ 5d$	$^1G^\circ$	4	16599.17	
$4f\ 5d$	$^3F^\circ$	2	17211.93	
		3	18235.56	1023.63
		4	19214.54	978.98
$4f\ 5d$	$^3H^\circ$	4	17825.62	
		5	18580.41	754.79
		6	19749.62	1169.21
$4f\ 5d$	$^1D^\circ$	2	18895.41	
$4f\ 5d$	$^3G^\circ$	3	20402.82	
		4	21331.60	928.78
		5	22282.90	951.30
$4f\ 5d$	$^3D^\circ$	1	21441.73	
		2	22106.02	664.29
		3	22537.30	431.28
$4f\ 5d$	$^3P^\circ$	0	22683.70	
		1	22705.15	21.45
		2	23246.93	541.78
$5d\ 6p$	$^1D^\circ$	2	24462.66	
$4f\ 5d$	$^1F^\circ$	3	24522.70	
$5d\ 6p$	$^3D^\circ$	1	25973.37	
		2	27388.11	1414.74
		3	28315.25	927.14
$5d\ 6p$	$^3F^\circ$	2	26414.01	
		3	26837.66	423.65
		4	28565.40	1727.74
$4f\ 5d$	$^1P^\circ$	1	27423.91	
$5d\ 6p$	$^3P^\circ$	0	27545.85	
		1	28154.55	608.70
		2	29498.05	1343.50
$4f\ 5d$	$^1H^\circ$	5	28525.71	
$5d\ 6p$	$^1P^\circ$	1	30353.33	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s\ 6p$	$^3P^\circ$	0	*31785.82*	
		1	*32160.99*	375.17
		2	*33204.41*	1043.42
$5d\ 6p$	$^1F^\circ$	3	*32201.05*	
$4f\ 6p$	^3G	3	35452.66	
		4	37172.79	1720.13
		5	39018.74	1845.95
$4f\ 6p$	^3F	2	35787.53	
		3	36954.65	1167.12
		4	37790.57	835.92
$4f\ 6p$	^1F	3	37209.71	
$4f\ 6p$	^3D	1	38534.11	
		2	38221.49	−687.38
		3	39402.55	1181.06
$4f\ 6p$	^1G	4	39221.65	
$4f\ 6p$	^1D	2	40457.71	
$6s\ 6p$	$^1P^\circ$	1	*45692.17*	
$5d\ 7s$	^3D	1	49733.13	
		2	49884.35	151.22
		3	51228.57	1344.22
$5d\ 7s$	^1D	2	51523.86	
$5d\ 6d$	^1F	3	52137.67	
$5d\ 6d$	^3D	1	52169.66	
		2	52734.81	565.15
		3	53689.56	954.75
$5d\ 6d$	^3G	3	52857.88	
		4	53333.37	475.49
		5	54434.65	1101.28
$5d\ 6d$	^3P	0	53011.27	
		1	53302.56	291.29
		2	54365.80	1063.24

LANTHANUM II

(Concluded)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d\ 6d$	^1D	2	53885.24	
$5d\ 6d$	^1S	0	54793.82	
$4f^2$	^3H	4	55107.25	
				874.84
		5	55982.09	
				855.85
		6	56837.94	
$5d\ 6d$	^3F	2	55184.05	
				−344.01
		3	54840.04	
				481.31
		4	55321.35	
$5d\ 6d$	^3S	1	55230.33	
$5d\ 6d$	^1G	4	56035.70	
$5d\ 6d$	^1P	1	56036.60	
$4f^2$	^3F	2	57399.58	
				518.92
		3	57918.50	
				340.91
		4	58259.41	
$4f^2$	^1G	4	59527.60	
$4f^2$	^1D	2	59900.08	
$6p^2$	^3P	0	60094.84	
				1033.99
		1	61128.83	
				1377.53
		2	62506.36	
$6p^2$	^1D	2	62026.27	
$4f^2$	^1I	6	62408.40	
$4f^2$	^3P	0	63463.95	
				139.23
		1	63603.18	
				675.74
		2	64278.92	
—	^3D	1	64361.28	
				168.62
		2	64529.90	
				162.69
		3	64692.59	
$6p^2$	^1S	0	66591.91	
$4f^2$	^1S	0	69505.06	

La III $Z = 57$

55 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ 5d\ ^2D_{1\frac{1}{2}}$

Ionization potential about 20.4 volts

This spectrum has been classified by means of comparison with isoelectronic spectra. The lowest state has been found from extrapolation to be 166000 cm.$^{-1}$ with respect to $5p^6\ ^1S_0$ of La IV.

References

J. S. Badami, *Proc. Lond. Phys. Soc.* **43**, 53 (1931).
R. C. Gibbs and H. E. White, *Phys. Rev.* **33**, 157 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	0 1603.8	1603.8
$6s$	^2S	$\frac{1}{2}$	13590.0	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*42014.0* *45109.4*	3095.4
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	82378.6 82810.4	431.8

Li I $\qquad Z = 3$

3 electrons $\qquad 1s^2\, 2s\ ^2S_{\frac{1}{2}}$

First ionization potential = 5.37 volts

The classification is taken from Fowler and Paschen-Götze. Only the first term of the p series has been resolved into a doublet. Its separation is 0.34 cm.$^{-1}$.

Two types of tables are given: first, one containing only the lowest terms, second, one containing the complete set of terms in series arrangement.

Configuration	Symbol	J	Term value
$2s$	^2S	$\frac{1}{2}$	43486.3
$2p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*28582.5*
$3s$	^2S	$\frac{1}{2}$	16280.5
$3p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*12560.4*
$3d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	12203.1
$4s$	^2S	$\frac{1}{2}$	8475.2
$4p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*7018.2*
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	6863.5
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*6856.1*

mp			
m	$^2P_{\frac{1}{2},\,1\frac{1}{2}}^{\circ}$	m	$^2P_{\frac{1}{2},\,1\frac{1}{2}}^{\circ}$
2	*28582.5*	22	*228.3*
3	*12560.4*	23	*209.9*
4	*7018.2*	24	*188.9*
5	*4473.6*	25	*175.8*
6	*3099.2*	26	*160.8*
7	*2273.3*	27	*149.9*
8	*1736.3*	28	*142.0*
9	*1372.7*	29	*131.1*
10	*1113.6*	30	*122.5*
11	*917.2*	31	*114.6*
12	*771.7*	32	*107.8*
13	*658.3*	33	*101.4*
14	*560.7*	34	*95.0*
15	*490.7*	35	*90.9*
16	*429.4*	36	*85.8*
17	*381.2*	37	*81.6*
18	*340.3*	38	*77.7*
19	*304.9*	39	*73.9*
20	*275.0*	40	*69.4*
21	*248.9*	41	*65.4*
		42	*62.0*

ms	
m	$^2S_{\frac{1}{2}}$
2	43486.3
3	16280.5
4	8475.2
5	5187.8
6	3500.4
7	2535.6

md	
m	$^2D_{1\frac{1}{2},\,2\frac{1}{2}}$
3	12203.1
4	6863.5
5	4389.6
6	3047.0
7	2237.4
8	1699.0
9	1345.2

mf	
m	$^2F_{2\frac{1}{2},\,3\frac{1}{2}}^{\circ}$
4	*6856.1*
5	*4381.8*

Li II $\qquad Z = 3$

2 electrons $\qquad 1s^2\ ^1S_0$

Ionization potential = 75.282 volts

These terms were obtained from papers by Werner and Schüler. The lowest state has been found by Ericson and Edlén.

The relative position of the singlets with respect to the triplets may be a few frequency units in error.

Schüler discovered interesting hyperfine structure, due to both nuclear spin and isotope shift. The interpretation and investigation are still in progress.

References

S. Werner, *Nature* **116,** 574 (1925); **118,** 154 (1926).
H. Schüler, *Zeits. f. Physik* **37,** 568 (1926); **42,** 487 (1927).
A. Ericson and B. Edlén, *Zeits. f. Physik* **59,** 656 (1930).
P. Güttinger and W. Pauli, *Zeits. f. Physik* **67,** 743 (1931). Hyperfine structure.

Configuration	Symbol	J	Term value	
$1s^2$	^1S	0	610112	
$1s\ 2s$	^3S	1	134033	
$1s\ 2s$	^1S	0	[120000]	Calculated
$1s\ 2p$	$^3P^\circ$	0, 1, 2	*115806*	
$1s\ 2p$	$^1P^\circ$	1	*108264*	
$1s\ 3s$	^3S	0, 1, 2	55318	
$1s\ 3s$	^1S	0	51300	
$1s\ 3p$	$^3P^\circ$	0, 1, 2	*50578*	
$1s\ 3d$	^3D	1, 2, 3	48834	

(*Continued*)

Configuration	Symbol	J	Term value
1s 3d	^1D	2	48804
1s 3p	$^1P°$	1	*48330*
1s 4s	^3S	1	30097
1s 4s	^1S	0	28488
1s 4p	$^3P°$	0, 1, 2	*28187*
1s 4d	^3D	1, 2, 3	27467
1s 4d	^1D	2	27448
1s 4f	$^3F°$	2, 3, 4	*27435*
1s 4f	$^1F°$	3	*27434*
1s 4p	$^1P°$	1	*27245*
1s 5s	^3S	1	18895
1s 5s	^1S	0	18095
1s 5p	$^3P°$	0, 1, 2	*17938*
1s 5d	^3D	1, 2, 3	17574
1s 5d	^1D	2	17570
1s 5f	$^1F°$	3	*17558*
1s 5f	$^3F°$	2, 3, 4	*17552*
1s 5p	$^1P°$	1	*17440*
1s 6s	^3S	1	12957
1s 6s	^1S	0	12505
1s 6p	$^3P°$	0, 1, 2	*12413*
1s 6d	^3D	1, 2, 3	12203

LITHIUM II

(*Concluded*)

Configuration	Symbol	J	Term value
1s 6d	^1D	2	12202
1s 6f	$^3F^\circ$	2, 3, 4	*12193*
1s 6f	$^1F^\circ$	3	*12192*
1s 7s	^3S	1	9438
1s 7s	^1S	0	9154
1s 7d	^3D	1, 2, 3	8964
1s 7d	^1D	2	8964
1s 7f	$^3F^\circ$	2, 3, 4	*8958*
1s 7f	$^1F^\circ$	3	*8957*
1s 8d	^1D	2	6865
1s 8f	$^1F^\circ$	3	*6858*

Li III $\qquad Z = 3$

1 electron $\qquad 1s\ ^2S_{\frac{1}{2}}$

Ionization potential = 121.8 volts

For a more detailed discussion compare H I. The term values of this spectrum are given by

$$\frac{E(n, l, j)}{hc} = \frac{R_{Li} \times 9}{n^2} + \frac{5.822 \times 81}{n^3}\left(\frac{3}{4n} - \frac{1}{j + \frac{1}{2}}\right)$$

where

$$R_{Li} = R \Big/ \left(1 + \frac{m}{M_{Li}}\right) = 109727.5 \text{ and } 109728.9$$

As Li has two isotopes there are two values for R_{Li}, which at present cannot be distinguished experimentally. Edlén and Ericson located the first two lines of the Lyman series of this spectrum; they are at λ 135.02 and λ 113.93.

The fine structure could not be observed.

Reference

B. Edlén and A. Ericson, *Nature* **125**, 233 (1930).

Mg I $\qquad Z = 12$

12 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\ {}^1S_0$

First ionization potential = 7.61 volts

The classification can be found for the greater part in Paschen-Götze and Fowler. Several tables are given: the first containing the lowest terms only, the second containing the $3p^2$ group found by Millikan and Bowen, and other tables containing all terms arranged according to series.

Reference

R. A. Millikan and I. S. Bowen, *Phys. Rev.* **26,** 150 (1925):

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2$	${}^1S$	0	61672.1	
$3s\,3p$	${}^3P^\circ$	0 1 2	*39821.3* *39801.4* *39760.5*	19.9 40.9
$3p$	${}^1P^\circ$	1	*26620.7*	
$4s$	${}^3S$	1	20474.5	
$4s$	${}^1S$	0	18169.0	
$3d$	${}^1D$	2	15268.9	
$4p$	${}^3P^\circ$	0, 1 2	*13824.1* *13820.0*	4.1
$3d$	${}^3D$	1, 2, 3	13714.7	
$4p$	${}^1P^\circ$	1	*12325.5*	
$5s$	${}^3S$	1	9779.3	
$5s$	${}^1S$	0	9115.8	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d$	^1D	2	8537.4	
$4d$	^3D	1, 2, 3	7479.5	
$5p$	$^3P^\circ$	0, 1, 2	*7419.0*	
$4f$	$^3F^\circ$	2, 3, 4	*6994.8*	
$3p^2$	^3P	0 1 2	3860.4 3839.6 3799.0	20.8 40.6
$3p^2$	^1D	2	3650	

SERIES

3s ms		
m	$^1S_0$	$^3S_1$
3	61672.1	
4	18169.0	20474.5
5	9115.8	9799.3
6	5485.7	5781.3
7	3661.6	3817.0
8		2709.1
9		2022.1
10		1567.0
11		1250.3

3s mp				
m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	$^1P_1^\circ$
3	*39821.3*	*39801.4*	*39760.5*	*26620.7*
4	*13824.1*	—	*13820.0*	*12325.5*
5	*7919.0*	Unresolved		*6970*
6	*4653.2*	—	*4651.9*	
7	*3184.5*	Unresolved		

3s md		
m	$^1D_2$	$^3D_{1,2,3}$
3	15268.9	13714.7
4	8537.4	7479.5
5	5363.6	4704.1
6	3648.7	3229.3
7	2631.6	2352.9
8	1982.7	1790.3
9	1544.9	1408.5
10	1237.0	1136.4
11	1012.3	936.1
12	835.4	784.2
13	716.2	667.6
14		574.0

3s mf	
m	$^3F^\circ_{2,3,4}$
4	*6994.8*
5	*4669.0*

Mg II $\quad Z = 12$

11 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 14.96 volts

The classification is taken from Paschen-Götze and Fowler. The first table contains only the lowest states. The other tables contain all terms arranged in series.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s$	^2S	$\frac{1}{2}$	121267.4	
$3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*85597.99* *85506.44*	91.5
$4s$	^2S	$\frac{1}{2}$	51462.2	
$3d$	^2D	$1\frac{1}{2}$ $\frac{1}{2}$	49777.0 49776.0	−1.0
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*40646.6* *40616.1*	30.5
$5s$	^2S	$\frac{1}{2}$	38481.2	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*23812.5* *23789.4*	23.1
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	27955.3	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*27467.4*	
$6s$	^2S	$\frac{1}{2}$	18069.3	
$5d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	17846.3	
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*17577.2*	

SERIES

ms	
m	$^2S_{\frac{1}{2}}$
3	121267.4
4	51462.2
5	28481.2
6	18069.3
7	12482.7
8	9137.6
9	6975.2

mp		
m	$^2P_{\frac{1}{2}}^{\circ}$	$^2P_{1\frac{1}{2}}^{\circ}$
3	*85597.94*	*85506.44*
4	*40646.6*	*40616.1*
5	*23812.5*	*23798.4*
6	*15644.3*	*15636.7*

md	
m	$^2D_{1\frac{1}{2},\,2\frac{1}{2}}$
3	49777.0
4	27955.3
5	17846.3
6	12366.5
7	9069.4
8	6931.7

mf	
m	$^2F_{2\frac{1}{2},\,3\frac{1}{2}}^{\circ}$
4	*27467.4*
5	*17577.2*
6	*12204.8*
7	*8965.6*
8	*6863.8*
9	*5422.3*
10	*4391.7*
11	*3629.1*
12	*3049.4*

mg	
m	$^2G_{3\frac{1}{2},\,4\frac{1}{2}}$
5	
6	12194.2
7	8957.2
8	6858.8
9	5418.8
10	4389.2
11	3626.8
12	3047.2

Mg III $\qquad$ $Z = 12$

10 electrons $\qquad$ $1s^2\ 2s^2\ 2p^6\ {}^1S_0$

First ionization potential = 80 ± 2 volts

The classification has been given by Mack and Sawyer, and Edlén and Erickson. The notation is the same as for Ne I.

References

J. E. Mack and R. A. Sawyer, *Science* **68,** 306 (1928).
B. Edlén and A. Ericson, *Comptes Rendus* **190,** 116 (1930).

	Configuration	Symbol	J	Term value
	$2p^6$	^1S	0	0
s_5	$2p^5\ (^2P_{1\frac{1}{2}})\ 3s$	1°	2	*425645*
s_4		2°	1	*426861*
s_3	$2p^5\ (^2P_{\frac{1}{2}})\ 3s$	3°	0	*427838*
s_2		4°	1	*431526*
p_{10}	$2p^5\ (^2P_{1\frac{1}{2}})\ 3p$	1	1	466234
p_9		2	3	473551 or 474125 or 474270
p_8		3	2	474533
p_7		4	1	475527
p_6		5	2	477580
p_3		6	0	477973 or 478425
p_5	$2p^5\ (^2P_{\frac{1}{2}})\ 3p$	7	1	477625
p_4		8	2	477915
p_2		9	1	480253
p_1		10	0	482935 or 484077

Mg IV $Z = 12$

9 electrons $1s^2\,2s^2\,2p^5\ {}^2P_{1\frac{1}{2}}^{\circ}$

This spectrum has been studied by Mack and Sawyer and by Edlén and Ericson. They have located a doublet in the far ultra-violet by means of the irregular doublet law.

References

B. Edlén and A. Ericson, *Comptes Rendus* **190**, 173 (1930).
J. E. Mack and R. A. Sawyer, *Phys. Rev.* **35**, 299 (1930).

Configuration	Symbol	J	Term value
$2s^2\,2p^5$	$^2P^{\circ}$	$1\frac{1}{2}$	*0*
		$\frac{1}{2}$	*2219*
$2s\ 2p^6$	^2S	$\frac{1}{2}$	311543

Mg V $\quad Z = 12$

8 electrons $\quad 1s^2\,2s^2\,2p^4\;{}^3P_2$

These terms are from the work of Mack and Sawyer who have located a $PP°$ group by use of the irregular doublet law.

References

J. E. Mack and R. A. Sawyer, *Phys. Rev.* **35**, 299 (1930).
B. Edlén and A. Ericson, *Comptes Rendus* **190**, 173 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^4$	${}^3P$	2	0	
				−1610
		1	1610	
				−930
		0	2540	
$2s\;2p^5$	${}^3P°$	2	*283260*	
				−1810
		1	*285070*	
				−730
		0	*285800*	

Mn I $\qquad Z = 25$

25 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2\ {}^6S_{2\frac{1}{2}}$

First ionization potential = 7.41 volts

This is the spectrum in which Catalán discovered multiplets for the first time.

The absolute term values are given with respect to $3d^5\ 4s\ {}^7S$ of Mn II.

White and Ritschl interpreted the hyperfine structure and found for the nuclear moment $I = 2\frac{1}{2}$.

References

M. A. Catalán, *Trans. Roy. Soc.* **A223,** 127 (1922).

E. Back, *Zeits. f. Physik* **15,** 206 (1923). Zeeman effect.

R. A. Sawyer, *Nature* **117,** 155 (1925).

J. C. McLennan and A. B. McLay, *Trans. Roy. Soc. Can.* **20,** 15 (1926).

H. N. Russell, *Astrophys. Journ.* **66,** 184, 223 (1927).

M. A. Catalán, *An. Soc. Españ. Fis. y Quim.* **26,** 250, 67, (1928).

H. E. White and R. Ritschl, *Phys. Rev.* **35,** 1146 (1930). Hyperfine structure.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5\ 4s^2$	$a\ {}^6S$	$2\frac{1}{2}$	59937.47	
$3d^6\ ({}^5D)\ 4s$	$a\ {}^6D$	$4\frac{1}{2}$	42885.17	
				−229.67
		$3\frac{1}{2}$	42655.50	
				−169.54
		$2\frac{1}{2}$	42485.96	
				−116.98
		$1\frac{1}{2}$	42368.98	
				−68.70
		$\frac{1}{2}$	42300.28	
$3d^5\ 4s\ ({}^7S)\ 4p$	$z\ {}^8P^\circ$	$2\frac{1}{2}$	*41534.98*	
				129.18
		$3\frac{1}{2}$	*41405.80*	
				173.71
		$4\frac{1}{2}$	*41232.09*	
$3d^6\ ({}^5D)\ 4s$	$a\ {}^4D$	$3\frac{1}{2}$	36640.81	
				−252.52
		$2\frac{1}{2}$	36388.29	
				−170.30
		$1\frac{1}{2}$	36217.00	
				−99.30
		$\frac{1}{2}$	36118.69	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5\,4s\,(^7S)\;4p$	$z\,^6P^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	*35158.16* *35149.46* *35135.24*	8.70 14.22
$3d^5\,4s\,(^5S)\;4p$	$a\,^4P^\circ$	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*28936.41* *28861.11* *28812.58*	−75.30 −48.53
$3d^5\,4s\,(^5S)\;4p$	$y\,^6P^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	*24247.40* *24211.65* *24167.53*	35.75 44.12
$3d^5\,4s\,(^7S)\;5s$	$a\,^8S$	$3\frac{1}{2}$	20506.13	
$3d^5\,4s\,(^7S)\;5s$	$b\,^6S$	$2\frac{1}{2}$	18533.50	
$3d^6\,(^5D)\;4p$	$z\,^6D^\circ$	$4\frac{1}{2}$ $3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*18148.04* *18004.88* *17883.78* *17793.97* *17738.89*	−143.16 −121.10 −89.81 −55.08
$3d^6\,(^5D)\;4p$	$z\,^6F^\circ$	$5\frac{1}{2}$ $4\frac{1}{2}$ $3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*16624.24* *16508.92* *16413.39* *16342.01* *16293.02* *16264.47*	−115.32 −95.53 −71.38 −48.99 −28.55
$3d^6\,(^5D)\;4p$	$z\,^4F^\circ$	$4\frac{1}{2}$ $3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$	*15648.72* *15414.02* *15241.20* *15122.88*	−234.70 −172.82 −188.32
$3d^6\,(^5D)\;4p$	$x\,^6P^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$	*14943.59* *14781.39* *14678.29*	−162.60 −103.10
$3d^6\,(^5D)\;4p$	$z\,^4D^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	*14183.22* *13996.53* *13853.59* *13767.56*	−186.69 −142.94 −86.03
—	$y\,^8P^\circ$?	$2\frac{1}{2}, 3\frac{1}{2}, 4\frac{1}{2}$	*13956.10* ?	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5\ 4s\ (^7S)\ 4d$	$a\ ^8D$	$1\frac{1}{2}$	13231.30	0.92
		$2\frac{1}{2}$	13230.38	1.26
		$3\frac{1}{2}$	13229.12	1.85
		$4\frac{1}{2}$	13227.27	2.34
		$5\frac{1}{2}$	13224.93	
$3d^6\ (^5D)\ 4p$	$y\ ^4P^\circ$	$2\frac{1}{2}$	*13036.35*	−253.37
		$1\frac{1}{2}$	*12782.98*	−144.79
		$\frac{1}{2}$	*12638.19*	
$3d^5\ 4s\ (^7S)\ 4d$	$b\ ^6D$	$4\frac{1}{2}$	12730.20	−4.74
		$3\frac{1}{2}$	12725.46	−3.56
		$2\frac{1}{2}$	12721.90	−2.55
		$1\frac{1}{2}$	12719.35	−1.58
		$\frac{1}{2}$	12717.77	
—	$y\ ^6F^\circ$	$5\frac{1}{2}$	*11916.15*	−146.56
		$4\frac{1}{2}$	*11769.56*	−57.99
		$3\frac{1}{2}$	*11711.57*	−44.92
		$2\frac{1}{2}$	*11666.65*	−30.12
		$1\frac{1}{2}$	*11636.53*	−17.16
		$\frac{1}{2}$	*11619.37*	
$3d^5\ 4s\ (^5S)\ 4d$?	$a\ ^6D$?	—	10524.27	
$3d^5\ 4s\ (^5S)\ 5s$	$a\ ^4S$	$1\frac{1}{2}$	10346.03	
—	$w\ ^6P^\circ$	$3\frac{1}{2}$	*10049.50*	−124.35
		$2\frac{1}{2}$	*9925.15*	−86.80
		$1\frac{1}{2}$	*9838.35*	
$3d^5\ 4s\ (^7S)\ 6s$	$b\ ^8S$	$3\frac{1}{2}$	9779.89	
$3d^5\ 4s\ (^7S)\ 6s$	$c\ ^6S$	$2\frac{1}{2}$	9032.89	
—	$a\ ^8P$?	$2\frac{1}{2}$	7448.47	7.38
		$3\frac{1}{2}$	7441.09	9.52
		$4\frac{1}{2}$	7431.57	
$3d^5\ 4s\ (^7S)\ 5d$	$b\ ^8D$	—	7234.7	
$3d^5\ 4s\ (^7S)\ 4f$	$z\ ^8F^\circ$	—	*6962.9*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$v\,^6P^\circ$	$3\frac{1}{2}$	*6668.12*	
				−42.05
		$2\frac{1}{2}$	*6626.07*	
				−21.39
		$1\frac{1}{2}$	*6604.68*	
$3d^5\,4s\,(^7S)\;7s$	$c\,^8S$	$3\frac{1}{2}$	5757.40	
—	$d\,^6S$	$2\frac{1}{2}$	5477.7	
	$d\,^6D$	$4\frac{1}{2}$	4999.0	
				−7.5
		$3\frac{1}{2}$	4991.5	
				−4.4
		$2\frac{1}{2}$	4987.3	
				−2.5
		$1\frac{1}{2}$	4984.3	
	$b\,^8P$	—	4675.35	
$3d^5\,4s\,(^7S)\;6d$	$c\,^8D$?	—	4561.8	
$3d^5\,4s\,(^7S)\;5f$	$y\,^8F^\circ$?	—	*4438.3*	
$3d^5\,4s\,(^7S)\;8s$	$d\,^8S$	$3\frac{1}{2}$	3793.1	
$3d^5\,4s\,(^7S)\;7d$	$d\,^8D$?	—	3145.3	
$3d^5\,4p^2$	$c\,^8P$	$2\frac{1}{2}$	2851.44	
				132.08
		$3\frac{1}{2}$	2719.36	
				170.67
		$4\frac{1}{2}$	2548.69	
—	$b\,^4D$	$3\frac{1}{2}$	2631.82	
				−180.34
		$2\frac{1}{2}$	2451.48	
				−135.86
		$1\frac{1}{2}$	2315.62	
				− 83.94
		$\frac{1}{2}$	2231.68	

Mn II $Z = 25$

24 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s\ {}^7S_3$

First ionization potential = 15.70 volts

The terms of singly ionized manganese are from Russell's paper with the exception of $3d^5\,5s\ {}^5S$ which is from Catalán. The absolute value of the lowest state is about 126800 cm.$^{-1}$

References

H. N. Russell, *Astrophys. Journ.* **66**, 233 (1927).
M. A. Catalán, *An. Soc. Españ.* **26**, 67 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^5\,({}^6S)\,4s$	${}^7S$	3	0	
$3d^5\,({}^6S)\,4s$	${}^5S$	2	9472.86	
$3d^6$	${}^5D$	4	14324.47	
				−269.29
		3	14593.76	
				−187.32
		2	14781.08	
				−120.00
		1	14901.08	
				−58.59
		0	14959.67	
$3d^5\,({}^6S)\,4p$	${}^7P^\circ$	2	*38366.03*	
				176.91
		3	*38542.94*	
				263.58
		4	*38806.52*	
$3d^5\,({}^6S)\,4p$	${}^5P^\circ$	3	*43370.40*	
				−114.08
		2	*43484.48*	
				−72.45
		1	*43556.93*	
$3d^5\,({}^6S)\,5s$	${}^7S$	3	74558.69	
$3d^5\,({}^6S)\,5s$	${}^5S$	2	76382.18	
$3d^5\,({}^6S)\,4d$	${}^7D$	1	79540.1	
				3.7
		2	79543.8	
				5.4
		3	79549.2	
				9.0
		4	79558.2	
				10.2
		5	79568.4	

Mn III $\qquad Z = 25$

23 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ {}^6S_{2\frac{1}{2}}$

By means of a study of isoelectronic spectra, Gibbs and White have been able to identify a single multiplet of Mn III. The lowest state is probably the $3d^5\ {}^6S_{2\frac{1}{2}}$ which has not been found.

Reference

R. C. Gibbs and H. E. White, *Proc. Nat. Acad. Sci.* **13**, 525 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^4\,4s$	^6D	$\frac{1}{2}$	0.0	
		$1\frac{1}{2}$	132.2	132.2
		$2\frac{1}{2}$	311.7	179.5
		$3\frac{1}{2}$	553.0	241.3
		$4\frac{1}{2}$	849.6	296.6
$3d^4\,4p$	$^6F^\circ$	$\frac{1}{2}$	*47578.3*	
		$1\frac{1}{2}$	*47736.3*	158.0
		$2\frac{1}{2}$	*47962.1*	225.8
		$3\frac{1}{2}$	*48275.2*	313.1
		$4\frac{1}{2}$	*48675.0*	399.8
		$5\frac{1}{2}$	*49165.3*	490.3

Mn IV $Z = 25$

22 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^4\;{}^5D_0$

White has identified a multiplet by use of the irregular doublet law in an isoelectronic sequence.

Reference

H. E. White, *Phys. Rev.* **33**, 914 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\,({}^4F)\,4s$	${}^5F$	1	0	
				204
		2	204	
				302
		3	506	
				394
		4	900	
				475
		5	1375	
$3d^3\,({}^4F)\,4p$	${}^5G^\circ$	2	*56383*	
				410
		3	*56793*	
				535
		4	*57328*	
				661
		5	*57989*	
				786
		6	*58775*	

Mn V $\quad Z = 25$

21 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ {}^4F_{1\frac{1}{2}}$

First ionization potential = 76 volts

This classification is given by White. The absolute value of the lowest state is estimated to be 613000 cm.$^{-1}$ with respect to 3d^2 ^3F of Mn VI.

Reference

H. E. White, *Phys. Rev.* **33**, 678 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3$	^4F	$1\frac{1}{2}$	0	
				333
		$2\frac{1}{2}$	333	
				497
		$3\frac{1}{2}$	830	
				572
		$4\frac{1}{2}$	1402	
$3d^3$	^2G	$3\frac{1}{2}$	17852	
				556
		$4\frac{1}{2}$	18408	
$3d^3$	^2H	$4\frac{1}{2}$	24935	
				426
		$5\frac{1}{2}$	25361	
$3d^2\ (^3F)\ 4s$	^4F	$1\frac{1}{2}$	176938	
				390
		$2\frac{1}{2}$	177328	
				551
		$3\frac{1}{2}$	177879	
				700
		$4\frac{1}{2}$	178579	
$3d^2\ (^3F)\ 4s$	^2F	$2\frac{1}{2}$	183466	
				1159
		$3\frac{1}{2}$	184625	
$3d^2\ (^3F)\ 4p$	$^4G^\circ$	$2\frac{1}{2}$	*241898*	
				869
		$3\frac{1}{2}$	*242767*	
				1040
		$4\frac{1}{2}$	*243807*	
				1244
		$5\frac{1}{2}$	*245051*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3F)\ 4p$	$^4F^\circ$	$1\frac{1}{2}$	*243112*	
				568
		$2\frac{1}{2}$	*243680*	
				705
		$3\frac{1}{2}$	*244385*	
				756
		$4\frac{1}{2}$	*245141*	
$4p$	$^2F^\circ$	$2\frac{1}{2}$	*245418*	
				911
		$3\frac{1}{2}$	*246329*	
$4p$	$^4D^\circ$	$3\frac{1}{2}$	*247713*	
$4p$	$^2G^\circ$	$3\frac{1}{2}$	*250893*	
				815
		$4\frac{1}{2}$	*251708*	

Mn VII $\qquad Z = 25$

19 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d\ ^2D_{1\frac{1}{2}}$

A doublet line was found by Gibbs and White. The lowest state has not been found.

Reference

R. C. Gibbs and H. E. White, Proc. Nat. Acad. Sci. **12**, 676 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s$	^2S	$\frac{1}{2}$	0	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*78913.5* *81378.2*	2464.7

Mo I $\qquad Z = 42$

42 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^5\,5s\;{}^7S_3$

Ionization potential = 7.35 volts

These terms have been taken from papers by Catalán, and Meggers and Kiess. The division into multiplets is rather uncertain and it is difficult to obtain the character of some of the multiplets.

References

M. A. Catalán, *An. Soc. Españ. Fis. y Quim.* **21**, 213 (1923).
W. F. Meggers and C. C. Kiess, *Journ. Opt. Soc. Am.* **12**, 417 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$	
$4d^5\,({}^6S)\,5s$	$a\,{}^7S$	3	59560.4		
$4d^5\,({}^6S)\,5s$	$a\,{}^5S$	2	48792.2		
$4d^4\,5s^2$	$a\,{}^5D$	0	48594.6		
				177.0	
		1	48417.6		
				311.5	
		2	48106.1		
				404.2	
		3	47701.9		
				487.8	
		4	47214.1		
$4d^5\,({}^4G)\,5s$	$a\,{}^5G$	2	42919.6		
				51.9	
		3	42867.7		
				54.9	
		4	42812.8		
				36.7	
		5	42776.1		
				43.8	
		6	42732.3		
—	$a\,{}^5P$	3	41331.5		$3d^4\,({}^4D)\,4s\;{}^3D$?
				−127.3	
		2	41204.2		
				−123.3	
		1	41080.9		
$4d^5\,({}^6S)\,5p$	$z\,{}^7P^\circ$	2	*33946.1*		
				257.51	
		3	*33688.6*		
				448.6	
		4	*33240.0*		

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	
$4d^5\ (^6S)\ 5p$	$z\ ^5P^\circ$	1	*30845.3*	121.5	
		2	*30723.8*	86.9	
		3	*30636.9*		
—	$y\ ^7P^\circ$	2	*28260.5*	233.3	
		3	*28027.2*	279.9	
		4	*27647.3*		
—	$z\ ^5D^\circ$	0	*26908.2*	246.5	
		1	*26661.7*	400.3	
		2	*26261.4*	656.0	
		3	*25605.4*	1126.1	
		4	*24479.3*		
—	$z\ ^7D^\circ$	1	*25312.2*	186.4	
		2	*25125.8*	305.7	
		3	*24820.1*	429.0	
		4	*24391.1*	549.9	
		5	*23841.2*		
—	$y\ ^5D^\circ$	0	*22460.4*	192.9	
		1	*22267.5*	286.2	
		2	*21981.3*	389.3	
		3	*21592.2*	454.6	
		4	*21137.6*		
$4d^5\ (^6S)\ 6s$	$b\ ^7S$	3	19885.0		
$4d^5\ (^6S)\ 6s$	$b\ ^5S$	2	18720.1		
—	$z\ ^5F^\circ$	1	*18548.9*	20.2	
		2	*18528.7*	192.5	
		3	*18336.2*	171.1	
		4	*18165.1*	303.0	
		5	*17862.1*		
$4d^5\ (^6S)\ 5d$	$a\ ^7D$	1	14624.7	4.7	
		2	14620.0	6.9	
		3	14613.1	9.8	
		4	14603.3	12.8	
		5	14590.5		

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^5\ (^6S)\ 5d$	$b\ ^5D$	4	13774.8	
				7.2
		3	13767.6	
				7.2
		2	13760.4	
				5.2
		1	13755.2	
				2.6
		0	13752.6	
$4d^5\ (^6S)\ 7s$	$c\ ^5S$	2	9455.3	

Mo II $Z = 42$

41 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^4\ 5s\ {}^6D_{\frac{1}{2}}$

Several multiplets in the first spark spectrum of Mo have been given by Meggers and Kiess. No intercombinations have been found, so the sextets and quartets are given separately.

Reference

W. F. Meggers and C. C. Kiess, *Journ. Opt. Soc. Am.* **12**, 435 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^4\ ({}^5D)\ 5s$	${}^6D$	$\frac{1}{2}$	0	
		$1\frac{1}{2}$	250.70	250.70
		$2\frac{1}{2}$	633.85	383.15
		$3\frac{1}{2}$	1116.75	482.90
		$4\frac{1}{2}$	1677.21	560.46
$5p$	${}^6D^\circ$	$\frac{1}{2}$	*38166.04*	
		$1\frac{1}{2}$	*38408.51*	242.47
		$2\frac{1}{2}$	*38208.51*	−200.00
		$3\frac{1}{2}$	*38518.84*	310.33
		$4\frac{1}{2}$	*38921.74*	402.90
$5p$	${}^6F^\circ$	$\frac{1}{2}$	*34069.69*	
		$1\frac{1}{2}$	*34364.59*	294.80
		$2\frac{1}{2}$	*34830.69*	466.10
		$3\frac{1}{2}$	*35448.45*	617.76
		$4\frac{1}{2}$	*36215.94*	767.49
		$5\frac{1}{2}$	*37176.21*	960.27

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^4\ ({}^5D)\ 5s$	${}^4D$	$\frac{1}{2}$	0	
		$1\frac{1}{2}$	287.15	287.15
		$2\frac{1}{2}$	740.19	453.04
		$3\frac{1}{2}$	1442.13	701.94

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^4\,5p$?	$^4P^\circ$	$\frac{1}{2}$	*22836.26*	
		$1\frac{1}{2}$	*23650.32*	814.06
		$2\frac{1}{2}$	*24631.80*	981.48
$5p$?	$^4D^\circ$	$\frac{1}{2}$	*25577.35*	
		$1\frac{1}{2}$	*25819.93*	242.58
		$2\frac{1}{2}$	*26205.71*	385.78
		$3\frac{1}{2}$	*26806.51*	600.80
$5p$?	$^4F^\circ$	$1\frac{1}{2}$	*27001.60*	
		$2\frac{1}{2}$	*27360.35*	359.15
		$3\frac{1}{2}$	*27845.28*	484.93
		$4\frac{1}{2}$	*28813.61*	968.33

N I $Z = 7$

7 electrons $1s^2\,2s^2\,2p^3\;{}^4S_{1\frac{1}{2}}$

First ionization potential = 14.48 volts

The classification of the arc spectrum of nitrogen has been given here according to Ingram. This classification, in addition to giving new terms, reviews all the previous work. Hopfield has reported the finding of several higher series members in the s series but no change is found in the ionization potential.

References

S. B. Ingram, *Phys. Rev.* **34**, 421 (1929).
J. J. Hopfield, *Phys. Rev.* **36**, 789 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^3$	${}^4S^\circ$	$1\frac{1}{2}$	*117345*	
$2p^3$	${}^2D^\circ$	$1\frac{1}{2}, 2\frac{1}{2}$	*98143*	
$2p^3$	${}^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*88537*	
$2p^2({}^3P)\,3s$	${}^4P$	$\frac{1}{2}$	34059.5	
		$1\frac{1}{2}$	34025.7	33.8
		$2\frac{1}{2}$	33979.0	46.7
$({}^3P)\,3s$	${}^2P$	$\frac{1}{2}$	31239.1	
		$1\frac{1}{2}$	31156.0	83.1
$2s\,2p^4$	${}^4P$	$2\frac{1}{2}$	29235.5	
		$1\frac{1}{2}$	29191.6	−43.9
		$\frac{1}{2}$	29172.0	−19.6
$2s^2\,2p^2\,({}^3P)\,3p$	${}^2S^\circ$	$\frac{1}{2}$	*23794.7*	
$({}^3P)\,3p$	${}^4D^\circ$	$\frac{1}{2}$	*22572.8*	
		$1\frac{1}{2}$	*22550.2*	22.6
		$2\frac{1}{2}$	*22512.9*	37.3
		$3\frac{1}{2}$	*22461.9*	51.9

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^2\,(^3P)\,3p$	$^4P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*21868.5* *21850.1* *21811.8*	18.4 38.3
$(^3P)\,3p$	$^4S^\circ$	$1\frac{1}{2}$	*20593.3*	
$(^3P)\,3p$	$^2D^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$	*20588.8* *20512.8*	76.0
$(^3P)\,3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*19606.9* *19571.2*	35.7
$(^1D)\,3s$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	17701 ?	
$(^3P)\,4s$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	13726.9 13676.9 13608.2	50.0 68.7
$(^3P)\,4s$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	13232.3 13154.9	77.4
$(^3P)\,3d$	^2P	$1\frac{1}{2}$ $\frac{1}{2}$	12761.6 12722.1	−39.5
$(^3P)\,3d$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	12688 ? 12660.8 ? 12626.5 ? 12577 ?	27.2 34.3 49.5
$(^3P)\,3d$	^2F	$2\frac{1}{2}$ $3\frac{1}{2}$	12566.1 12494.3	71.8
$(^3P)\,3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	12256.2 12232.7	23.5
$(^3P)\,3d$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	12481 12455 12388	26 67
$(^3P)\,3d$	^4D	$2\frac{1}{2}$ $3\frac{1}{2}$	12334.3 12325.5	8.8
$(^3P)\,4p$	$^2S^\circ$	$\frac{1}{2}$	*10898.4*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2 2p^2 (^3P) 4p$	$^4D^\circ$	$\frac{1}{2}$	*10584.5*	19.6
		$1\frac{1}{2}$	*10564.9*	36.0
		$2\frac{1}{2}$	*10528.9*	54.6
		$3\frac{1}{2}$	*10474.3*	
$(^3P) 4p$	$^4P^\circ$	$\frac{1}{2}$	*10362.3*	15.6
		$1\frac{1}{2}$	*10346.7*	40.7
		$2\frac{1}{2}$	*10306.0*	
$(^3P) 4p$	$^4S^\circ$	$1\frac{1}{2}$	*9897.8*	
$(^3P) 5s$	^4P	$\frac{1}{2}$	7531.5	54.3
		$1\frac{1}{2}$	7487.2	70.1
		$2\frac{1}{2}$	7417.1	
$(^3P) 5s$	^2P	$\frac{1}{2}$	7340	76
		$1\frac{1}{2}$	7264	
$(^3P) 4d$	^4F	$1\frac{1}{2}$	7149.1	17.8
		$2\frac{1}{2}$	7131.3	34.7
		$3\frac{1}{2}$	7096.6	56.0
		$4\frac{1}{2}$	7040.6	
$(^3P) 4d$	^2P	$1\frac{1}{2}$	7156.2	−25.0
		$\frac{1}{2}$	7131.2	
$(^3P) 4d$	^4D	$\frac{1}{2}$	7123.6	54.1
		$1\frac{1}{2}$	7069.5	12.3
		$2\frac{1}{2}$	7057.2	50.9
		$3\frac{1}{2}$	7006.3 ?	
$(^3P) 4d$	^2F	$2\frac{1}{2}$	7066	62
		$3\frac{1}{2}$	7004	
$(^3P) 4d$	^4P	$\frac{1}{2}$	7020.3	26.3
		$1\frac{1}{2}$	6994 ?	51.8
		$2\frac{1}{2}$	6942.2	
$(^1D) 3p$	$^2D^\circ$	$1\frac{1}{2}$	*6855.1*	23.5
		$2\frac{1}{2}$	*6831.6*	
$(^1D) 3p$	$^2P^\circ$	$\frac{1}{2}$	*5082.2*	26.0
		$1\frac{1}{2}$	*5056.2*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^2\,(^3P)\,6s$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	4779.1 4734.4 4662.4	44.7 72.0
$(^3P)\,6s$	^2P	$1\frac{1}{2}$	4554	
$(^3P)\,5d$	^2P	$1\frac{1}{2}$	4575.5	
$(^3P)\,5d$	^4F	$3\frac{1}{2}$ $4\frac{1}{2}$	4546.4 4482.5	63.9
$(^3P)\,5d$	^4D	$2\frac{1}{2}$	4520	
$(^3P)\,5d$	^2F	$3\frac{1}{2}$	4472	
$(^3P)\,5d$	^4P	$1\frac{1}{2}$ $2\frac{1}{2}$	4471 4433.1	37.9
$(^3P)\,7s$	^4P	$2\frac{1}{2}$	3198.5	
$(^3P)\,7s$	^2P	$1\frac{1}{2}$	3183	
$(^3P)\,6d$	^4D	$2\frac{1}{2}$	3157	
$(^3P)\,6d$	^2F	$3\frac{1}{2}$	3096	
$(^3P)\,6d$	^4P	$2\frac{1}{2}$	3070.8	
$(^3P)\,7d$	^4P	$2\frac{1}{2}$	2242	

N II $\qquad\qquad$ $Z = 7$

6 electrons $\qquad\qquad$ $1s^2\ 2s^2\ 2p^2\ {}^3P_0$

First ionization potential = 29.47 volts

The classification has been given by Fowler and Freeman and by Bowen. Many terms are known, but not many series members. Intercombinations between the triplets and singlets have been found but not between the quintets and triplets so the quintets are given separately. The absolute value of the lowest state has been given by Fowler and Freeman to be 238849 cm.$^{-1}$ with respect to the $2p\ {}^2P_{\frac{1}{2}}$ level of N III.

References

A. Fowler and L. J. Freeman, *Proc. Roy. Soc.* **A114**, 662 (1927).
I. S. Bowen, *Phys. Rev.* **29**, 231 (1927); **34**, 534 (1929).
L. J. Freeman, *Proc. Roy. Soc.* **A124**, 654 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^2$	^3P	0	0	
		1	50	50
		2	134	84
$2p^2$	^1D	2	15320	
$2p^2$	^1S	0	32692	
$2s\ 2p^3$	$^3D^\circ$	3	*92238*	
		2, 1	*92252*	−14
$2s\ 2p^3$	$^3P^\circ$	1, 2	*109218*	
		0	*109223*	−5
$2s^2\ 2p\ 3s$	$^3P^\circ$	0	*148911.7*	
		1	*148943.3*	31.6
		2	*149079.6*	136.3
$2p\ 3s$	$^1P^\circ$	1	*149190.0*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p^3$	$^3S^\circ$	1	*155127*	
$2s^2\,2p\ 3p$	^1D	2	164613.9	
$2p\ 3p$	^3D	1 2 3	166524.8 166585.6 166681.7	60.8 96.2
$2p\ 3p$	^3S	1	168895.3	
$2p\ 3p$	^3P	0 1 2	170575.7 170610.9 170699.3	35.2 58.4
$2p\ 3p$	^1P	1	174215.2	
$2p\ 3p$	^1S	0	178276.5	
$2p\ 3d$	$^3F^\circ$	2 3 4	*186514.7* *186574.1* *186655.7*	59.4 55.6
$2p\ 3d$	$^1F^\circ$	3	*186681.0*	
$2p\ 3d$	$^1P^\circ$	1	*187094.5*	
$2p\ 3d$	$^3D^\circ$	1 2 3	*187440.6* *187464.7* *187495.0*	24.1 30.3
$2p\ 3d$	$^3P^\circ$	2 1 0	*188860.4* *188912.2* *188940.3*	−51.8 −28.1
$2p\ 3d$	$^1D^\circ$	2	*190123.4*	
$2p\ 4s$	$^3P^\circ$	0 1 2	*196543.4* *196595.2* *196714.5*	51.8 119.3
$2p\ 4s$	$^1P^\circ$	1	*197861.6*	
$2p\ 4p$	^1S	0	202172.2	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p\ 4p$	^1D	2	202695.7	
$2p\ 4p$	^3D	1	202717.2	
				51.0
		2	202768.2	
				96.2
		3	202864.4	
$2p\ 4p$	^3P	0	203167.0	
				24.1
		1	203191.1	
				70.9
		2	203262.0	
$2p\ 4p$	^3S	1	203535.1	
$2p\ 4d$	$^3F°$	2	*209677.6*	
				64.2
		3	*209741.8*	
				85.8
		4	*209827.6*	
$2p\ 4d$	$^1D°$	2	*209929.2*	
$2p\ 4d$	$^3D°$	1	*210242.1*	
				26.5
		2	*210268.6*	
				35.6
		3	*210304.2*	
$2p\ 4d$	$^3P°$	2	*210707.7*	
				−46.1
		1	*210753.8*	
				−25.5
		0	*210779.3*	
$2p\ 5s$	$^3P°$	0	*214214.7*	
				45.8
		1	*214260.5*	
				127.1
		2	*214387.6*	
$2p\ 5s$	$^1P°$	1	*214830.3*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p^3$	$^5S°$	2	*0.0*	
$2s\ 2p^2\ 3s$	^5P	1	158812.4	
				56.0
		2	158868.4	
				70.6
		3	158939.0	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p^2\ 3p$	$^5D^\circ$	0	*176857.4*	
		1	*176873.2*	15.8
		2	*176902.6*	29.4
		3	*176945.7*	43.1
		4	*176999.6*	53.9
$2s\ 2p^2\ 3p$	$^5P^\circ$	1	*178817.4*	
		2	*178841.5*	24.1
		3	*178885.5*	44.0
$2s\ 2p^2\ 3p$	$^5S^\circ$	2	*183053.3*	
$2s\ 2p^2\ 3d$	^5F	1	196185.8	
		2	196201.5	15.7
		3	196226.9	25.4
		4	196260.5	33.6
		5	196301.1	40.6
$2s\ 2p^2\ 3d$	^5P	3	197567.7	
		2	197606.2	−38.5
		1	197632.3	−26.1
$2s\ 2p^2\ 3d$	^5D	0	198150.1	
		1	198153.7	3.6
		2	198161.6	7.9
		3	198173.2	11.6
		4	198187.2	14.0

N III $\quad Z = 7$

4 electrons $\quad 1s^2\, 2s^2\, 2p\ ^2P_{\frac{1}{2}}^\circ$

First ionization potential = 47.40 volts

The classification has been given by Freeman. As there were no intercombinations found between the doublets and quartets they are given in separate tables. Bowen found, in the far ultra-violet, a combination of quartet levels which have not yet been connected with the other levels and are also given in a separate table.

The absolute value of the lowest state $2s^2\, 2p\ ^2P_{\frac{1}{2}}^\circ$ is calculated to be 384088.4 cm.$^{-1}$ with respect to $2s^2\ ^1S_0$ of N IV. The absolute value of $2s\, 2p\, 3s\ ^4P_{\frac{1}{2}}$ is 16078.3 referred to $2s\, 2p\ ^3P_0$ of N IV. The distance between these two states of N IV is estimated to be about 58000 cm.$^{-1}$. The $2s\, 2p^2\ ^4P_{\frac{1}{2}}$ is about 310487 from the $^1S_0$ limit.

References

I. S. Bowen, *Phys. Rev.* **29,** 231 (1927).

L. J. Freeman, *Proc. Roy. Soc.* **A121,** 318 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\, 2p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*0* *174.4*	174.4
$2s\ 2p^2$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	101029.8 101024.1	−5.7
$2s\ 2p^2$	^2S	$\frac{1}{2}$	131002.0	
$2s\ 2p^2$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	145874.4 145985.2	110.8
$2p^3$	$^2D^\circ$	$2\frac{1}{2}$ $1\frac{1}{2}$	*203070.9* *203087.5*	−16.6

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,3s$	^2S	$\frac{1}{2}$	221290.1	
$2p^3$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*230392.2* *230396.4*	4.2
$2s^2\,3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*245653.4* *245689.4*	36.0
$2s^2\,3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	267226.2 267232.1	5.9
$3s^2\,4s$	^2S	$\frac{1}{2}$	301075	
$3s^2\,4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*311679.0* *311703.8*	24.8
$3s^2\,4f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*321409*	
$3s^2\,5d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	343211 ?	
$3s^2\,5g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	344239	
$3s^2\,6g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	356336.7	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p\ 3s$	$^4P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*0* *62.5* *178.3*	62.5 115.8
$2s\ 2p\ 3p$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	22127.2 22162.7 22224.9 22321.1	35.5 62.2 96.2
$2s\ 2p\ 3p$	^4S	$1\frac{1}{2}$	26688.4	
$2s\ 2p\ 3p$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	29764.3 29807.8 29866.7	43.5 58.9

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p\ 3d$	$^4F^{\circ}$	$1\frac{1}{2}$	*42702.8*	
		$2\frac{1}{2}$	*42737.9*	35.1
		$3\frac{1}{2}$	*42789.7*	51.8
		$4\frac{1}{2}$	*42861.1*	71.4
$2s\ 2p\ 3d$	$^4D^{\circ}$	$\frac{1}{2}$	*45261.0*	
		$1\frac{1}{2}$	*45274.4*	13.4
		$2\frac{1}{2}$	*45296.4*	22.0
		$3\frac{1}{2}$	*45324.7*	28.3
$2s\ 2p\ 3d$	$^4P^{\circ}$	$2\frac{1}{2}$	*48677.8*	
		$1\frac{1}{2}$	*48732.4*	−54.6
		$\frac{1}{2}$	*48767.5*	−35.1
$2s\ 2p\ 4s$	$^4P^{\circ}$	$\frac{1}{2}$	*80990.0*	
		$1\frac{1}{2}$	*81052.7*	62.7
		$2\frac{1}{2}$	*81169.2*	116.5
$2s\ 2p\ 4p$	^4D	$\frac{1}{2}$	89221.0	
		$1\frac{1}{2}$	89267.7	46.7
		$2\frac{1}{2}$	89328.2	60.5
		$3\frac{1}{2}$	89417.7	89.5
$2s\ 2p\ 4p$	^4S	$1\frac{1}{2}$	90904.9	
$2s\ 2p\ 4p$	^4P	$\frac{1}{2}$	91771.7	
		$1\frac{1}{2}$	91816.5	44.8
		$2\frac{1}{2}$	91869.4	52.9
$2s\ 2p\ 4d$	$^4F^{\circ}$	$1\frac{1}{2}$	—	
		$2\frac{1}{2}$	*96480*	
		$3\frac{1}{2}$	*96529*	49
		$4\frac{1}{2}$	*96603*	74
$2s\ 2p\ 4d$	^4D	$\frac{1}{2}$	—	
		$1\frac{1}{2}$	97760	
		$2\frac{1}{2}$	97787	27
		$3\frac{1}{2}$	97816	29

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p^2$	^4P	$\frac{1}{2}$	0	
		$1\frac{1}{2}$	60.3	60.3
		$2\frac{1}{2}$	140.8	80.5
$2p^3$	$^4S^{\circ}$	$1\frac{1}{2}$	*129610.1*	

N IV $\quad\quad Z = 7$

4 electrons $\quad\quad 1s^2\ 2s^2\ {}^1S_0$

Ionization potential = 77 volts

These terms are taken from the work of Freeman, from the work of Edlén, and from unpublished material of Bowen. No intercombinations between singlets and triplets have been found. Edlén gives the absolute value of the lowest singlet state as 624300 cm.$^{-1}$.

In addition to the terms given here, Freeman denotes the following lines as ${}^3F$—${}^3G$ combinations:

$\nu = 37768.9 \quad 2s\ 4f\ {}^3F_4^\circ$—$2s\ 5g\ {}^3G_5$
$\nu = 37780.1 \quad 2s\ 4f\ {}^3F_3^\circ$—$2s\ 5g\ {}^3G_4$
$\nu = 37787.7 \quad 2s\ 4f\ {}^3F_2^\circ$—$2s\ 5g\ {}^3G_3$

References

L. J. Freeman, *Proc. Roy. Soc.* **A127**, 330 (1930).
I. S. Bowen and R. A. Millikan, *Phys. Rev.* **26,** 150 (1925).
B. Edlén, *Nature* **127,** 744 (1931).
I. S. Bowen, Unpublished material.

Configuration	Symbol	J	Term value
$2s^2$	${}^1S$	0	0
$2s\ 2p$	${}^1P^\circ$	1	*130687*
$2p^2$	${}^1D$	2	188876
$2p^2$	${}^1S$	0	235363
$2s\ 3p$	${}^1P^\circ$	1	*404524*

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\,2p$	$^3P^\circ$	0	*0*	
		1	*68*	68
		2	*204*	136
$3p^2$	^3P	0	108330	
		1	108393	63
		2	108525	132

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\,3s$	^3S	1	0	
$2s\,3p$	$^3P^\circ$	0	*28687.1*	
		1	*28702.9*	15.8
		2	*28738.3*	35.4
$2s\,3d$	^3D	1	42761.2	
		2	42764.7	3.5
		3	42773.3	8.6

N V $\qquad\qquad$ $Z = 7$

3 electrons $\qquad\qquad$ $1s^2\ 2s\ ^2S_{\frac{1}{2}}$

Ionization potential = 97.43 volts

Edlén and Ericson give the absolute value of the lowest state as 789591 cm.$^{-1}$.

Reference

B. Edlén and A. Ericson, Zeits. f. Physik **64**, 64 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$1s^2\ 2s$	^2S	$\frac{1}{2}$	0	
$2p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*80455* *80714*	259
$3s$	^2S	$\frac{1}{2}$	455974	
$3p$	$^2P^\circ$	$\frac{1}{2}, 1\frac{1}{2}$	*477829*	
$3d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	484381	

Na I $\qquad Z = 11$

11 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 5.12 volts

This spectrum has been taken from Paschen-Götze and Fowler. It is interesting to note that 57 members of the p series are known.

Two types of tables are given, the first one containing only the lowest terms, followed by the complete set of terms in series arrangement.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s$	^2S	$\frac{1}{2}$	41449.0	
$3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*24492.83* *24475.65*	17.18
$4s$	^2S	$\frac{1}{2}$	15709.50	
$3d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	12276.18	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*11181.63* *11176.14*	5.49
$5s$	^2S	$\frac{1}{2}$	8248.28	
$4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	6900.35	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*6860.37*	

SERIES

mp		
m	$^2P_{\frac{1}{2}}{}^\circ$	$^2P_{1\frac{1}{2}}{}^\circ$
3	*24492.83*	*24475.65*
4	*11181.63*	*11176.14*
5	*6408.83*	*6406.34*
6	*4152.80*	*4151.30*
7	*2908.93*	*2907.46*
8	*2150.69*	*2149.80*
9	*1655.31*	*1654.08*

mp (*Continued*)

m	$^2P^\circ_{\frac{1}{2},1\frac{1}{2}}$	m	$^2P^\circ_{\frac{1}{2},1\frac{1}{2}}$	m	$^2P^\circ_{\frac{1}{2},1\frac{1}{2}}$	m	$^2P^\circ_{\frac{1}{2},1\frac{1}{2}}$
10	*1312.28*	24	*204.65*	38	*79.73*	52	*41.94*
11	*1065.86*	25	*187.93*	39	*75.50*	53	*40.31*
12	*883.40*	26	*173.30*	40	*71.65*	54	*38.81*
13	*743.31*	27	*160.28*	41	*68.09*	55	*37.43*
14	*634.92*	28	*149.12*	42	*64.88*	56	*36.07*
15	*548.13*	29	*137.93*	43	*61.85*	57	*35.03*
16	*478.59*	30	*128.66*	44	*58.95*	58	*34.39*
17	*421.10*	31	*120.33*	45	*56.25*	59	*33.78*
18	*373.86*	32	*112.83*	46	*53.84*		
19	*333.47*	33	*106.14*	47	*51.54*		
20	*299.54*	34	*99.89*	48	*49.39*		
21	*270.33*	35	*94.17*	49	*47.34*		
22	*245.09*	36	*88.97*	50	*45.47*		
23	*223.35*	37	*84.19*	51	*43.63*		

ms

m	$^2S_{\frac{1}{2}}$
3	41449.00
4	15709.50
5	8248.28
6	5077.31
7	3437.28
8	2480.65
9	1874.49
10	1466.0
11	1175.5
12	966.1
13	804.4
14	679.5

md

m	$^2D_{1\frac{1}{2},2\frac{1}{2}}$
3	12276.18
4	6900.35
5	4412.47
6	3061.92
7	2248.56
8	1720.88
9	1357.2
10	1098.7
11	907.1
12	761.7
13	647.7
14	559.0
15	491

mf

m	$^2F^\circ_{2\frac{1}{2},3\frac{1}{2}}$
4	*6860.37*
5	*4390.37*

Na II $Z = 11$

10 electrons $1s^2\, 2s^2\, 2p^6\ {}^1S_0$

Ionization potential = 47.0 ± 0.5 volts

The classification of this spectrum has been given independently by several authors. The $2p^5\ ({}^2P_{\frac{1}{2}})\ 3s\ 1_2°$ term has been put equal to zero because the lowest state is not known with sufficient accuracy. For the notation compare Ne I. The absolute value of the lowest state is about 380950 cm.$^{-1}$ referred to $2p^5\ {}^2P_{\frac{1}{2}}$ of Na III.

References

I. S. Bowen, *Phys. Rev.* **31,** 967 (1928).
O. Laporte, *Nature* **121,** 941 (1928).
K. Mazumdar, *Indian Journ. Phys.* **2,** 345 (1928).
S. Frisch, *Zeits. f. Physik* **49,** 52 (1928).

	Configuration	Symbol	J	Term value	
	$2p^6$	^1S	0	−264950	
s_5	$2p^5\ ({}^2P_{1\frac{1}{2}})\ 3s$	1°	2	*0.0*	$^3P_2$
s_4		2°	1	*765.5*	$^3P_1$
s_3	$({}^2P_{\frac{1}{2}})\ 3s$	3°	0	*1357.5*	$^3P_0$
s_2		4°	1	*3838.5*	$^1P_1$
p_{10}	$2p^5\ ({}^2P_{1\frac{1}{2}})\ 3p$	1	1	28295.7	
p_9		2	3	32321.8	
p_8		3	2	32709.7	
p_7		4	1	33239.3	
p_6		5	2	34262.8	
p_3		6	0	33474.9	
p_5	$2p^5\ ({}^2P_{\frac{1}{2}})\ 3p$	7	1	34958.8	
p_4		8	2	35176.9	
p_2		9	1	35580.1	
p_1		10	0	39419.0	

(*Concluded*)

	Configuration	Symbol	J	Term value	
X_9	$2p^5\,3d$	1°	1 or 2	*65622.1*	
X_8	and	2°	1 or 2	*65708.7*	
X_7	$2p^5\,4s$	3°	2	*65858.0*	
X_6		4°	2	*66257.1*	
X_5		5°	2	*66566.8*	
X_4		6°	1	*67344.7*	
X_3		7°	0	*67781.6*	
X_2		8°	1 or 2	*68035.2*	
X_1		9°	1	*68179.0*	

Na III $\qquad Z = 11$

9 electrons $\qquad 1s^2\, 2s^2\, 2p^5\ {}^2P_{1\frac{1}{2}}^{\circ}$

The spectrum of twice ionized, sodium has been studied by Mack and Sawyer and by Edlén and Ericson. Using the irregular doublet law they have found a doublet in the far ultra-violet.

References

B. EDLÉN and A. ERICSON, *Comptes Rendus* **190**, 173 (1930).
J. E. MACK and R. A. SAWYER, *Phys. Rev.* **35**, 299 (1930).

Configuration	Symbol	J	Term value	
$2s^2\, 2p^5$	$^2P^{\circ}$	$1\frac{1}{2}$	*0*	
		$\frac{1}{2}$	*1371*	
$2s\ 2p^6$	^2S	$\frac{1}{2}$	264466	

Ne I $\qquad Z = 10$

10 electrons $\qquad 1s^2\, 2s^2\, 2p^6\; {}^1S_0$

Ionization potential = 21.47 volts

This classification has been taken almost entirely from Paschen-Götze. It was the first complicated spectrum ever analyzed and still is one of the few which are analyzed in great detail.

The Russell-Saunders symbols cannot be used here; the terms in each configuration are numbered consecutively. Since all configurations contain the p^5 group, one can omit it in abbreviated notations and can write, for instance,

$$3p\; 7_1 = 23157.34$$

To denote on which state of the ion the term is built, one can write

$$({}^2P_{\frac{1}{2}})\; 3p\; 7_1 = 23157.34$$

The original notation has been given for reference. Two tables are given. The first one contains only the lowest levels up to 14000 cm.$^{-1}$ The second set of tables contains all terms arranged according to series.

Several neon lines show hyperfine structure. It has been shown by Hansen, and by Nagaoka and Mishima, that this hyperfine structure is due to the fact that the p^5s levels are slightly different for the two principal neon isotopes.

References

E. Back, *Ann. d. Physik* **76**, 317 (1925). Zeeman effect.

T. Lyman and F. A. Saunders, *Proc. Nat. Acad. Sci.* **12**, 92 (1926). Lowest state from far ultra-violet observations.

W. Gremmer, *Zeits. f. Physik* **50**, 716 (1928). Some new terms from observations in the infra-red.

K. Murakawa and T. Iwana, *Inst. Phys. and Chem. Res., Tokio, Sci. Papers* **13**, 283 (1930). Zeeman effect.

H. Nagaoka and T. Mishima, *ibid.* **13**, 239 (1930). Hyperfine structure.

H. Hansen, *Naturwiss.* **15**, 163 (1927). Hyperfine structure.

	Configuration	Symbol	J	Term value		
$1P_0$	$2p^6$	^1S	0	173930		
$1s_5$	$2p^5\ (^2P_{1\frac{1}{2}})\ 3s$	1°	2	39887.61	$^3P_2$	g = 1.503
$1s_4$		2°	1	39470.16	$^3P_1$	g = 1.464
$1s_3$	$2p^5\ (^2P_{\frac{1}{2}})\ 3s$	3°	0	39110.81	$^3P_0$	
$1s_2$		4°	1	38040.73	$^1P_1$	g = 1.034
$2p_{10}$	$2p^5\ (^2P_{1\frac{1}{2}})\ 3p$	1	1	25671.65		g = 1.984
$2p_9$		2	3	24272.41		1.329
$2p_8$		3	2	24105.23		1.137
$2p_7$		4	1	23807.85		0.669
$2p_6$		5	2	23613.59		1.229
$2p_3$		6	0	23012.02		
$2p_5$	$2p^5\ (^2P_{\frac{1}{2}})\ 3p$	7	1	23157.34		g = 0.999
$2p_4$		8	2	23070.94		1.301
$2p_2$		9	1	22891.00		1.340
$2p_1$		10	0	20958.72		
$3d_6$	$2p^5\ (^2P_{1\frac{1}{2}})\ 3d$	1°	0	12419.87		g = 1.396
$3d_5$		2°	1	12405.23		1.24
$3d_4'$		3°	4	12339.15		
$3d_4$		4°	3	12337.32		1.374
$3d_3$		5°	2	12322.26		
$3d_2$		6°	1	12292.85		
$3d_1''$		7°	2	12229.82		
$3d_1'$		8°	3	12228.05		
$3s_1''''$	$2p^5\ (^2P_{\frac{1}{2}})\ 3d$	9°	2	11520.82		
$3s_1'''$		10°	3	11519.26		
$3s_1''$		11°	2	11509.50		
$3s_1'$		12°	1	11493.78		
$2s_5$	$2p^5\ (^2P_{1\frac{1}{2}})\ 4s$	1°	2	15328.31	$^3P_2$	
$2s_4$		2°	1	15133.47	$^3P_1$	
$2s_3$	$2p^5\ (^2P_{\frac{1}{2}})\ 4s$	3°	0	14549.47	$^3P_0$	
$2s_2$		4°	1	14395.75	$^1P_1$	

Additional g-values			
$2p^5\ (^2P_{1\frac{1}{2}})\ 4d$	3_4°	6929.46	g = 1.25
	4_3°	6928.37	1.06
$2p^5\ (^2P_{\frac{1}{2}})\ 4d$	11_2°	6132.51	1.269
	12_1°	6121.69	0.865

NEON I

SERIES

$2p^6\ {}^1S_0$
173930

m	$2p^5\ ({}^2P_{1\frac{1}{2}})\ ms$		$2p^5\ ({}^2P_{\frac{1}{2}})\ ms$	
	s_5 $1_2°$	s_4 $2_1°$	s_3 $3_0°$	s_2 $4_1°$
3	*39887.61*	*39470.16*	*39110.81*	*38040.73*
4	*15328.31*	*15133.47*	*14549.47*	*14395.75*
5	*8101.29*	*8016.68*	*7323.13*	*7272.96*
6	*5004.81*	*4962.10*	*4223.47*	*4201.81*
7	*3396.71*	*3372.37*	*2616.58*	*2605.42*
8	*2456.08*	*2439.97*	*1675.10*	*1667.66*
9	*1858.06*	*1848.55*	*1077.33*	*1072.45*
10	*1447.59*	*1447.59*	*674.19*	*670.01*
11	*1169.61*	*1164.91*	*389.45*	*386.17*
12	*960.90*	*957.06*		
13	*803.40*	*800.66*		

(*Continued*)

	$2p^5\,(^2P_{1\frac{1}{2}})\,mp$						$2p^5\,(^2P_{\frac{1}{2}})\,mp$			
m	p_{10} 1_1	p_9 2_3	p_8 3_2	p_7 4_1	p_6 5_2	p_3 6_0	p_5 7_1	p_4 8_2	p_2 9_1	p_1 10_0
3	25671.65	24272.41	24105.23	23807.85	23613.59	23012.02	23157.34	23070.94	22891.00	20958.72
4	11411.49	11098.72	11030.29	10916.78	10891 04	10528.09	10272.13	10220.82	10221.69	9643.51
5	6479.93	6370.29	6338.15	6289.81	6280.71	6062.15	5573.90	5550.65	5570.75	5342.44
6	4181.29	4132.28	4114.71	4089.95	4085.59	3952.65	3344.46	3332.15	3350.98	3240.04
7	2920.09	2896.54	2885.75	2871.44	2869.15	2780.61	2107.1	2101.4	2126.25	2015.95
8	2156.5	2142.4	2137.8	2126.25	2126.25	2015.95?	1355.8	1356.0		1264.31
9		1647.2	1642.6	1638.0	1638.0	1602.1	864.0			747.90
10		1306.2		1299.2	1299.2					422.90
11				1057.5	1057.5					232.8
12										115.4

NEON I

(Continued)

$2p^5\ (^2P_{1\frac{1}{2}})\ md$								
m	d_6 1_0°	d_5 2_1°	d_4' 3_4°	d_4 4_3°	d_3 5_2°	d_2 6_1°	d_1'' 7_2°	d_1' 8_3°
3	12419.87	12405.23	12339.15	12337.32	12322.26	12292.85	12229.82	12228.05
4	6961.80	6954.13	6929.46	6928.37	6917.92	6902.49	6881.85	6880.79
5	4446.44	4441.04	4427.77	4427.15	4420.88	4412.44	4403.13	4402.56
6	3081.24	3078.13	3070.96	3070.55	3066.46	3061.51	3056.56	3056.20
7	2260.27	2257.53	2254.01	2253.70	2248.11	2246.58	2244.17	2243.92
8	1729.08	1727.57	1724.34	1724.17	1722.66	1720.35	1718.37	1718.22
9	1364.55	1363.53	1361.57	1361.43	1360.06	1358.59	1357.33	1357.22
10	1104.86	1103.98	1102.31	1102.21	1101.55	1100.15	1099.25	1099.19
11	912.03	911.54	910.56	910.56	909.37		908.49	908.17
12		765.84	764.96	764.96	764.34		763.29	762.92
13		651.94	651.37	651.29	649.30			646.48

(*Concluded*)

$2p^5\ (^2P_{\frac{1}{2}})\ md$				
m	s_1'''' $9_2°$	s_1''' $10_3°$	s_1'' $11_2°$	s_1' $12_1°$
3	*11520.82*	*11519.26*	*11509.50*	*11493.78*
4	*6134.47*	*6133.56*	*6132.51*	*6121.69*
5	*3640.47*	*3639.75*	*3640.11*	*3633.43*
6	*2289.45*	*2287.02*	*2287.29*	*2284.57*
7	*1471.55*	*1470.82*	*1471.00*	*1468.40*
8	*942.35*	*942.21*	*942.30*	*940.43*
9	*579.93*	*579.92*	*579.98*	*578.64*
10	*320.93*	*320.90*	*320.98*	*319.94*
11	*129.10*	*129.10*	*129.1*	

$2p^5\ (^2P_{1\frac{1}{2}})\ mf$		
m	x 1_1	y 2_2
4	6876.73	6860.14

Ne II $\qquad Z = 10$

9 electrons $\qquad 1s^2\, 2s^2\, 2p^5\ {}^2P^\circ_{1\frac{1}{2}}$

Ionization potential = 40.9 ± 0.05 volts

The classification is given here according to the work of Russell, Compton, and Boyce. One additional doublet has been added by Frisch.

The lowest state is estimated to have an absolute value of 330429 cm.$^{-1}$ with respect to the $2s^2\, 2p^4\ {}^3P_2$ state of Ne III.

The classification of the $4f$ terms is doubtful.

References

H. N. Russell, K. T. Compton, and J. C. Boyce, *Proc. Nat. Acad. Sci.* **14,** 280 (1928).

K. T. Compton and J. C. Boyce, *Journ. Franklin Inst.* **205,** 497 (1928).

S. Frisch, *Zeits. f. Physik* **64,** 499 (1930).

T. L. de Bruin and C. J. Bakker, *Zeits. f. Physik* **69,** 19 (1931). Zeeman effect.

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\, 2p^5$	$^2P^\circ$	$1\frac{1}{2}$	*0*	
		$\frac{1}{2}$	*782*	−782
$2s\ 2p^6$	^2S	$\frac{1}{2}$	217053	
$2s^2\, 2p^4\ (^3P)\ 3s$	^4P	$2\frac{1}{2}$	219129	
		$1\frac{1}{2}$	219647	−518
		$\frac{1}{2}$	219946	−299
$(^3P)\ 3s$	^2P	$1\frac{1}{2}$	224085.3	
		$\frac{1}{2}$	224697.5	−612.2
$(^3P)\ 3p$	$^4P^\circ$	$2\frac{1}{2}$	*246190.8*	
		$1\frac{1}{2}$	*246413.6*	−222.8
		$\frac{1}{2}$	*246596.1*	−182.5
$(^1D)\ 3s$	^2D	$2\frac{1}{2}, 1\frac{1}{2}$	246379	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^4\,(^3P)\,3p$	$^4D^\circ$	$3\frac{1}{2}$	*249106.4*	
				−337.6
		$2\frac{1}{2}$	*249444.0*	
				−249.7
		$1\frac{1}{2}$	*249693.7*	
				−144.0
		$\frac{1}{2}$	*249837.7*	
$(^3P)\,3p$	$^2D^\circ$	$2\frac{1}{2}$	*251009.6*	
				−511.0
		$1\frac{1}{2}$	*251520.6*	
$(^3P)\,3p$	$^2S^\circ$	$\frac{1}{2}$	*252896.4*	
$(^3P)\,3p$	$^4S^\circ$	$1\frac{1}{2}$	*252951.5*	
$(^3P)\,3p$	$^2P^\circ$	$1\frac{1}{2}$	*254163.0*	
				−127.0
		$\frac{1}{2}$	*254290.0*	
$(^1D)\,3p$	$^2P^\circ$	$1\frac{1}{2}$	*276272.9*	
				−235.4
		$\frac{1}{2}$	*276508.3*	
$(^1S)\,3s$	^2S	$\frac{1}{2}$	276600.5	
$(^3P)\,3d$	^4D	$3\frac{1}{2}$	279135.5	
				−81.0
		$2\frac{1}{2}$	279216.5	
				−106.5
		$1\frac{1}{2}$	279323.0	
				−98.2
		$\frac{1}{2}$	279421.2	
$(^3P)\,3d$	^4F	$4\frac{1}{2}$	280170.6	
				−528.1
		$3\frac{1}{2}$	280698.7	
				−97.6
		$2\frac{1}{2}$	280795.3	
				−149.4
		$1\frac{1}{2}$	280944.7	
$(^3P)\,3d$	^2D	$2\frac{1}{2}$	280267.1	
				−756.8
		$1\frac{1}{2}$	281023.9	
$(^3P)\,3d$	^4P	$\frac{1}{2}$	280766.2	
				221.5
		$1\frac{1}{2}$	280987.7	
				181.8
		$2\frac{1}{2}$	281169.5	
$(^3P)\,3d$	^2P	$1\frac{1}{2}$	280330.4	
				−859.0
		$\frac{1}{2}$	280471.4	
$(^3P)\,4s$	^4P	$2\frac{1}{2}$	281996.4	
				−376.9
		$1\frac{1}{2}$	282373.3	
				−305.1
		$\frac{1}{2}$	282678.4	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2 2p^4 (^3P) 4s$	^2P	$1\frac{1}{2}$	283320.6	
		$\frac{1}{2}$	283892.5	−571.9
$(^3P) 4f$?	$^4D^\circ$	$3\frac{1}{2}$	*302827.0*	
		$2\frac{1}{2}$	*302842.0*	−15.0
		$1\frac{1}{2}$	*302900.9*	−58.9
		$\frac{1}{2}$	*302987.6*	−86.7
$(^3P) 4f$?	$^4F^\circ$	$4\frac{1}{2}$	*302902.3*	
		$3\frac{1}{2}$	*303526.7*	−624.4
		$2\frac{1}{2}$	*303822.7*	−296.0
		$1\frac{1}{2}$	*303507.3*	315.4
$4f$?	1°	$1\frac{1}{2}$	*303598.5*	

Ne III $\qquad$ $Z = 10$

8 electrons $\qquad$ $1s^2\,2s^2\,2p^4\;{}^3P_2$

Ionization potential = 63.2 volts

Boyce and Compton have given the lines classified as combinations between $2s^2\,2p^4$ and $2s\,2p^5$. They estimate the absolute value of the lowest state to be 511700 cm.$^{-1}$ referred to $2s^2\,2p^3\;{}^4S_{1\frac{1}{2}}$ of Ne IV.

Reference

J. C. Boyce and K. T. Compton, *Proc. Nat. Acad. Sci.* **15**, 656 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^4$	^3P	2	0	
				−640
		1	640	
				−260
		0	900	
$2s\;2p^5$	$^3P^\circ$	2	*204290*	
				−570
		1	*204860*	
				−330
		0	*205190*	

Ne IV $Z = 10$

7 electrons $1s^2\ 2s^2\ 2p^3\ {}^4S^\circ_{1\frac{1}{2}}$

Boyce and Compton have identified several lines in the far ultra-violet in the spectrum of Ne IV with the aid of extrapolation from other spectra. No intercombinations between the doublet and quartet terms were found.

Reference

J. C. Boyce and K. T. Compton, *Proc. Nat. Acad. Sci.* **15**, 656 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^3$	$^4S^\circ$	$1\frac{1}{2}$	*0*	
$2s\ 2p^4$	^4P	$2\frac{1}{2}$	183905	
				−590
		$1\frac{1}{2}$	184495	
				−348
		$\frac{1}{2}$	184843	

Configuration	Symbol	J	Term value	
$2s^2\ 2p^3$	$^2D^\circ$	$2\frac{1}{2}$	*0*	
$2s^2\ 2p^3$	$^2P^\circ$	$1\frac{1}{2}$	*21216*	
$2s\ 2p^4$	^2D	$2\frac{1}{2}$	212897	
$2s\ 2p^4$	^2P	$1\frac{1}{2}$	278716	
$2s\ 2p^4$	^2P	$\frac{1}{2}$	279504	

Ni I $Z = 28$

28 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2\ {}^3F_4$

First ionization potential = 7.606 volts

Classification and assignments are taken from the work of Russell. Deviations from Russell-Saunders coupling are perhaps too great to allow definite multiplet assignments.

The absolute value of the lowest state is given as 61579 cm.$^{-1}$ with respect to $3d^9\ {}^2D_{2\frac{1}{2}}$.

Reference

H. N. Russell, Phys. Rev. **34**, 821 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8\ 4s^2$	^3F	4	0.00	
				−1332.15
		3	1332.15	
				−884.40
		2	2216.55	
$3d^9\ 4s$	^3D	3	204.82	
				−675.00
		2	879.82	
				−833.29
		1	1713.11	
$3d^9\ 4s$	^1D	2	3409.95	
$3d^8\ 4s^2$	^1D	2	13521.29	
$3d^{10}$	^1S	0	14728.92	
$3d^8\ 4s^2$	^3P	2	15609.81	
				−124.22
		1	15734.03	
				−283.27
		0	16017.30	
$3d^8\ 4s^2$	^1G	4	22102.27	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8\,4s$ (^4F) $4p$	$^5D^\circ$	4	25753.57	
				−912.40
		3	26665.97	
				−748.95
		2	27414.92	
				−528.66
		1	27943.58	
				−269.52
		0	28213.10	
$3d^8\,4s$ (^4F) $4p$	$^5G^\circ$	6	27260.96	
				−319.52
		5	27580.48	
				−487.70
		4	28068.18	
				−509.92
		3	28578.10	
				−435.18
		2	29013.28	
$3d^8\,4s$ (^4F) $4p$	$^5F^\circ$	5	28541.94	
				−542.53
		4	29084.47	
				−748.30
		3	29832.77	
				−330.39
		2	30163.16	
				−228.80
		1	30391.96	
$3d^9\,4p$	$^3P^\circ$	2	28569.30	
				−931.45
		1	29500.75	
				−691.55
		0	30192.30	
$3d^9\,4p$	$^3F^\circ$	3	29320.75	
		4	29480.96	
		2	30619.40	
$3d^9\,4p$	$^3D^\circ$	3	29668.89	
				−219.58
		2	29888.47	
				−1024.40
		1	30912.87	
$3d^8\,4s$ (^2F) $4p$	$^3G^\circ$	5	30922.61	
				−57.09
		4	30979.70	
				−806.43
		3	31786.13	
$3d^9\,4p$	$^1F^\circ$	3	31031.02	
$3d^9\,4p$	$^1D^\circ$	2	31441.64	
$3d^8\,4s$ (^2F) $4p$	$^3F^\circ$	4	32973.33	
				−138.97
		3	33112.30	
				−498.58
		2	33610.88	
$3d^9\,4p$	$^1P^\circ$	1	32982.30	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8\,4s\,(^2F)\,4p$	$^3D^\circ$	3 2 1	*33500.80* *34163.24* *34408.54*	−662.44 −245.30
$3d^8\,4s\,(^2F)\,4p$	$^1G^\circ$	4	*33590.12*	
$3d^8\,4s\,(^2F)\,4p$	$^1F^\circ$	3	*35639.09*	
$3d^8\,4s\,(^2F)\,4p$	$^1D^\circ$	2	*36600.78*	
—	1° 2°	3 2	*40361.10* *40484.10*	
$3d^8\,4s\,(^2D)\,4p$	$^3F^\circ$	4 3 2	*42585.04* *43654.91* —	−1069.87
$3d^9\,5s$	^3D	3 2 1	42605.84 42789.95 44112.13	−184.11 −1322.18
$3d^8\,4s\,(^2D)\,4p$	$^3D^\circ$	3 2 1	*42620.95* *42954.17* —	−333.22
$3d^8\,4s\,(^2D)\,4p$	$^3P^\circ$	2 1 0	*42653.65* *42656.27* —	−2.62
$3d^8\,4s\,(^4F)\,4p$	$^3D^\circ$	3 2 1	*42767.72* *44475.07* *45122.29*	−1707.35 −647.22
$3d^8\,4s\,(^4F)\,4p$	$^3G^\circ$	5 4 3	*43089.52* *44314.85* *45281.14*	−1225.33 −966.29
$3d^8\,4s\,(^4F)\,4p$	$^3F^\circ$	4 3 2	*43258.67* *44565.01* *45418.81*	−1306.34 −853.80
$3d^8\,4s\,(^2D)\,4p$	$^1P^\circ$	1	*43463.90*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8\,4s\,(^2D)\,4p$	$^1D^\circ$	2	*43933.37*	
$3d^8\,4s\,(^2D)\,4p$	$^1F^\circ$	3	*44206.42*	
$3d^9\,5s$	^1D	2	44262.52	
—	3°		*44336.10*	
$3d^8\,4s\,(^4P)\,4p$	$^3P^\circ$	2	*46522.77*	−685.36
		1	*47208.13*	−479.37
		0	*47687.50*	
$3d^8\,4s\,(^4P)\,4p$	$^3D^\circ$	3	*47029.98*	−109.27
		2	*47139.25*	−285.68
		1	*47424.93*	
—	4°	2	*47328.6*	
$3d^8\,4s\,(^4F)\,5s$	^5F	5	48466.52	−619.42
		4	49085.94	−691.57
		3	49777.51	−568.89
		2	50346.40	−398.17
		1	50744.57	
$3d^9\,5p$	$^3F^\circ$	3	*48671.9*	
		4	*48715.2*	
		2	*50038.8*	
$3d^9\,5p$	$^3P^\circ$	2	*48735.18*	−668.12
		1	*49403.30*	−735.08
		0	*50138.38*	
—	5°	1, 2	*48817.6*	
$3d^9\,4d$	^3S	1	48953.40	
—	6°	3	*49032.6*	
$3d^9\,4d$	^3G	5	49158.49	−16.11
		4	49174.60	−1502.93
		3	50677.53	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9\,4d$	^3P	2	49159.03	−11.95
		1	49170.98	−1105.37
		0	50276.35	
$3d^9\,5p$	$^3D^\circ$	2	*49184.8*	
		3	*49327.4*	
		1	*50851.0*	
$3d^9\,4d$	^3D	3	49271.35	−56.59
		2	49327.94	−1388.96
		1	50716.90	
$3d^9\,4d$	^3F	3	49313.51	
		4	49332.58	
		2	50834.30	
$3d^9\,5p$	$^1F^\circ$	3	*50142.8*	
$3d^9\,5p$	$^1P^\circ$	1	*50457.9*	
$3d^8\,4s\,(^4F)\,5s$	^3F	4	50466.08	−839.94
		3	51306.02	−734.44
		2	52040.46	
$3d^9\,4d$	^1P	1	50536.74	
$3d^9\,5p$	$^1D^\circ$	2	*50689.1*	
$3d^9\,4d$	^1G	4	50706.25	
$3d^9\,4d$	^1D	2	50754.11	
$3d^8\,4s\,(^2G)\,4p$	$^3F^\circ$	4	*50789.5*	−335.3
		3	*51124.8*	−218.8
		2	*51343.6*	
$3d^9\,4d$	^1F	3	50832.04	
$3d^9\,4d$	^1S	0	51457.20	
$3d^9\,6s$	^3D	3	52197.41	−74.24
		2	52271.65	−1432.13
		1	53703.78	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9\ 6s$	^1D	2	53753.89	
$3d^8\ 4s\ (^2F)\ 5s$	^3F	4	54237.10	
				−14.14
		3	54251.24	
				−1622.51
		2	55873.75	
$3d^9\ 5d$	^3S	1	54574.65	
$3d^9\ 5d$	^3G	5	54659.68	
				−8.17
		4	54667.85	
				−1504.79
		3	56172.64	
$3d^9\ 5d$	^3D	3	54699.58	
				−32.85
		2	54732.43	
		1	—	
$3d^9\ 5d$	^3F	4	54761.22	
				−10.97
		3	54772.19	
				−1502.15
		2	56274.34	
$3d^8\ 4s\ (^2F)\ 5s$	^1F	3	55576.76	
$3d^9\ 5d$	^1G	4	56183.19	
$3d^9\ 5d$	^1F	3	56263.05	
$3d^8\ 4s\ (^4F)\ 4d$	^3H	6	56624.60	
				−1052.90
		5	57677.50	
				−840.62
		4	58518.12	
$3d^8\ 4s\ (^4F)\ 4d$	^3P	2	56710.80	
				−1056.45
		1	57767.25	
				−681.37
		0	58448.62	
$3d^8\ 4s\ (^4F)\ 4d$	^3F	4	56766.40	
				−1201.74
		3	57968.14	
				−661.81
		2	58629.95	
$3d^8\ 4s\ (^4F)\ 4d$	^3G	5	56801.50	
				−988.04
		4	57789.54	
				−740.81
		3	58530.35	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^8\,4s\,(^4F)\,4d$	^5P	3	56821.42	−765.21
		2	57586.63	−938.95
		1	58525.58	
$3d^8\,4s\,(^4F)\,4d$	^5D	4	56857.93	−885.70
		3	57743.63	
$3d^8\,4s\,(^4F)\,4d$	^5H	7	56885.29	−876.66
		6	57761.95	−758.98
		5	58520.93	−518.80
		4	59039.73	−148.92
		3	59188.65	
$3d^8\,4s\,(^4F)\,4d$	^5G	6	56954.20	
		5	57829.38	
		3	58629.50	
		4	58872.72	
		2	59117.84	
$3d^8\,4s\,(^4F)\,4d$	^5F	5	56973.68	−836.67
		4	57810.35	−777.81
		3	58588.16	−404.26
		2	58992.42	−233.61
		1	59226.03	
$3d^8\,4s\,(^4F)\,4d$	^3D	3	57103.91	
$3d^8\,4s\,(^4F)\,6s$	^5F	5	59862.40	
$3d^8\,4s\,(^2F)\,4d$	^3F	4	61832.42	
$3d^8\,4s\,(^2F)\,4d$	^3G	5	61843.28	
$3d^8\,4s\,(^2F)\,4d$	^3H ?	6	61957.23	
$3d^8\,4s\,(^4F)\,5d$	^5H	7	62782.45	
$3d^8\,4s\,(^4F)\,5d$	^5G	6	62807.61	
$3d^8\,4s\,(^4F)\,5d$	^5F ?	5	62815.49	

Ni II $Z = 28$

27 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ {}^2D_{2\frac{1}{2}}$

First ionization potential = 18.2 volts

This spectrum has been analyzed by Shenstone and Menzies. Shenstone also investigated the Zeeman effect. The absolute value of the lowest state is 147000 cm.$^{-1}$ with respect to $3d^8\ {}^3F$ of Ni III.

References

A. G. Shenstone, *Phys. Rev.* **30**, 255 (1927).
A. C. Menzies, *Proc. Roy. Soc.* **A122**, 134 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^9$	^2D	$2\frac{1}{2}$	0	
				−1506.9
		$1\frac{1}{2}$	1506.9	
$3d^8\ (^3F)\ 4s$	^4F	$4\frac{1}{2}$	8392.9	
				−936.4
		$3\frac{1}{2}$	9329.3	
				−785.4
		$2\frac{1}{2}$	10114.7	
				−584.3
		$1\frac{1}{2}$	10663.0	
$(^3F)\ 4s$	^2F	$3\frac{1}{2}$	13549.1	
				−1445.3
		$2\frac{1}{2}$	14994.4	
$(^1D)\ 4s$	^2D	$2\frac{1}{2}$	23106.9	
				−688.0
		$1\frac{1}{2}$	23794.9	
$(^3P)\ 4s$	^4P	$1\frac{1}{2}$	24786.9	
		$\frac{1}{2}$	24834.7	
		$2\frac{1}{2}$	25034.6	
$(^3P)\ 4s$	^2P	$1\frac{1}{2}$	29069.4	
				−522.5
		$\frac{1}{2}$	29591.9	
$(^1G)\ 4s$	^2G	$4\frac{1}{2}$	32498.2	
				−24.0
		$3\frac{1}{2}$	32522.2	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$(^3F)\ 4p$	$^4D^\circ$	$3\frac{1}{2}$	51556.9	
				−1180.5
		$2\frac{1}{2}$	52737.4	
				−895.5
		$1\frac{1}{2}$	53633.9	
				−541.0
		$\frac{1}{2}$	54174.9	
$(^3F)\ 4p$	$^4G^\circ$	$4\frac{1}{2}$	53364.0	
		$5\frac{1}{2}$	53495.6	
		$3\frac{1}{2}$	54261.5	
		$2\frac{1}{2}$	55017.6	
$(^3F)\ 4p$	$^4F^\circ$	$4\frac{1}{2}$	54556.1	
				−860.6
		$3\frac{1}{2}$	55416.7	
				−657.3
		$2\frac{1}{2}$	56074.0	
				−349.4
		$1\frac{1}{2}$	56423.4	
$(^3F)\ 4p$	$^2G^\circ$	$4\frac{1}{2}$	55298.8	
				−1071.6
		$3\frac{1}{2}$	56370.4	
$(^3F)\ 4p$	$^2F^\circ$	$3\frac{1}{2}$	57079.1	
				−1412.7
		$2\frac{1}{2}$	58491.8	
$(^3F)\ 4p$	$^2D^\circ$	$2\frac{1}{2}$	57418.5	
				−1285.9
		$1\frac{1}{2}$	58704.4	
$(^3P)\ 4p$	$^4P^\circ$	$2\frac{1}{2}$	66569.7	
				−8.6
		$1\frac{1}{2}$	66578.3	
				−451.2
		$\frac{1}{2}$	67029.5	
$(^1D)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	67693.0	
				436.8
		$3\frac{1}{2}$	68129.8	
$(^1D)\ 4p$	$^2D^\circ$	$1\frac{1}{2}$	68152.9	
				581.2
		$2\frac{1}{2}$	68634.1	
$(^1D)\ 4p$	$^2P^\circ$	$\frac{1}{2}$	68180.2	
				684.1
		$1\frac{1}{2}$	68864.3	
$(^3P)\ 4p$	$^4D^\circ$	$2\frac{1}{2}$	70634.0	
		$1\frac{1}{2}$	70705.4	
		$\frac{1}{2}$	70747.3	
		$3\frac{1}{2}$	70776.2	
$(^3P)\ 4p$	$^2D^\circ$	$2\frac{1}{2}$	71769.7	
				−604.2
		$1\frac{1}{2}$	72373.9	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$(^3P)\ 4p$	$^2P^\circ$	$1\frac{1}{2}$	*72984.0*	−917.5
		$\frac{1}{2}$	*73801.5*	
$(^3P)\ 4p$	$^2S^\circ$	$\frac{1}{2}$	*74281.8*	
$(^3P)\ 4p$	$^4S^\circ$	$1\frac{1}{2}$	*74299.1*	
$(^1G)\ 4p$	$^2H^\circ$	$4\frac{1}{2}$	*75148.4?*	572.0
		$5\frac{1}{2}$	*75720.4?*	
$(^1G)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	*75888.3*	27.8
		$3\frac{1}{2}$	*75916.1*	
$(^1G)\ 4p$	$^2G^\circ$	$3\frac{1}{2}$	*79821.5*	101.1
		$4\frac{1}{2}$	*79922.6*	
$(^3F)\ 5s$	^4F	$4\frac{1}{2}$	92797.3	−525.4
		$3\frac{1}{2}$	93322.7	−1064.1
		$2\frac{1}{2}$	93386.8	−677.1
		$1\frac{1}{2}$	94063.9	
$(^3F)\ 5s$	^2F	$3\frac{1}{2}$	93525.1	−1200.8
		$2\frac{1}{2}$	94725.9	

O I $Z = 8$

8 electrons $1s^2\ 2s^2\ 2p^4\ ^3P_2$

First ionization potential = 13.550 volts

The terms in this table are taken from the most recent investigation of this spectrum by Hopfield, which is based on previous work by several other spectroscopists. The absolute term values are all given with respect to the $2p^3\ ^4S_{1\frac{1}{2}}$ level of O II, but many of them are actually built upon other states of O II, denoted in the configuration symbols. This causes many terms to have negative values.

Reference

J. J. Hopfield, *Phys. Rev.* **37**, 160 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^4$	^3P	2	109837.3	
		1	109679.17	−158.13
		0	109610.52	−68.65
$2p^4$	^1D	2	93969.5	
$2p^4$	^1S	0	76044.5	
$2p^3\ (^4S)\ 3s$	$^5S^\circ$	2	*36069.0*	
$2p^3\ (^4S)\ 3s$	$^3S^\circ$	1	*33043.3*	
$2p^3\ (^4S)\ 3p$	^5P	1	23211.9	
		2	23209.2	2.7
		3	23205.8	3.4
$2p^3\ (^4S)\ 3p$	^3P	0, 1	21207.7	
		2	21207.2	
$2p^3\ (^4S)\ 4s$	$^5S^\circ$	2	*14358.5*	
$2p^3\ (^4S)\ 4s$	$^3S^\circ$	1	*13612.5*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2p^3\ (^4S)\ 3d$	$^5D^\circ$	0, 1, 2, 3, 4	*12417.3*	
$2p^3\ (^4S)\ 3d$	$^3D^\circ$	1, 2, 3	*12350.0*	
$2p^3\ (^4S)\ 4p$	^5P	3 2 1	10744.3 10743.7 10742.5	−0.6 −1.2
$2p^3\ (^4S)\ 4p$	^3P	0, 1, 2	10157.5	
$2p^3\ (^2D)\ 3s$	$^3D^\circ$	3 2 1	*8702.9* *8690.9* *8683.0*	−12.0 −7.9
$2p^3\ (^4S)\ 5s$	$^5S^\circ$	2	*7720.8*	
$2p^3\ (^4S)\ 5s$	$^3S^\circ$	1	*7425.6*	
$2p^3\ (^2D)\ 3s$	$^1D^\circ$	2	*7168.5*	
$2p^3\ (^4S)\ 6s$	$^5S^\circ$	2	*4817.9*	
$2p^3\ (^4S)\ 6s$	$^3S^\circ$	1	*4672.8*	
$2p^3\ (^4S)\ 7s$	$^5S^\circ$	2	*3291.9*	
$2p^3\ (^4S)\ 7s$	$^3S^\circ$	1	*3210.2*	
$2p^3\ (^2D)\ 3p$	^3P	2 1	−3456.4 −3459.8	−3.4
$2p^3\ (^2D)\ 3p$	^3F	4 3 2	−3876.1 −3883.0 −3888.7	−6.9 −5.7
$2p^3\ (^2P)\ 3s$	$^3P^\circ$	2 1 0	*−4072.1* *−4082.5* *−4088.8*	−10.4 −6.3
$2p^3\ (^2P)\ 3s$	$^1P^\circ$	1	*−6083.5*	
$2p^3\ (^2D)\ 4s$	$^1D^\circ$	2	*−12964.5*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p^5$	$^3P^\circ$	2	*−13458.0*	−58.9
		1	*−13516.9*	−32.0
		0	*−13548.9*	
$2s^2\ 2p^3\ (^2D)\ 3d$	$^1F^\circ$	3	*−14487.5*	
$2p^3\ (^2D)\ 4p$	^3D	3	−15936.6	−7.4
		2	−15944.0	−5.0
		1	−15949.0	
$2p^3\ (^2P)\ 3p$	^3D	3	−17443.8	−5.7
		2	−17449.5	−3.4
		1	−17452.9	
$2p^3\ (^2D)\ 5s$	$^1D^\circ$	2	*−19295.5*	
$2p^3\ (^2D)\ 6s$	$^1D^\circ$	2	*−22088.5*	
$2p^3\ (^2D)\ 7s$	$^1D^\circ$	2	*−23574.5*	

O II $Z = 8$

7 electrons $1s^2\,2s^2\,2p^3\;{}^4S_{1\frac{1}{2}}^{\circ}$

First ionization potential 34.93 volts

The classification of the first spark spectrum of oxygen has been taken from the most recent work of Russell. He has given a complete term table. The absolute values have been determined by Fowler from a sequence of three s terms.

References

H. N. Russell, *Phys. Rev.* **31,** 27 (1928).
C. Mihul, *Ann. de Physique* **9,** 261 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^3$	${}^4S^{\circ}$	$1\frac{1}{2}$	*283028*	
$2s^2\,2p^3$	${}^2D^{\circ}$	$2\frac{1}{2}$ $1\frac{1}{2}$	*256210.5* *256190.7*	−29.8
$2s^2\,2p^3$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*242560.0* *242555.5*	4.5
$2s\;2p^4$	${}^4P$	$2\frac{1}{2}$ $1\frac{1}{2}$ $\frac{1}{2}$	163190 163027 162945	−163 −82
$2s\;2p^4$	${}^2D$	$2\frac{1}{2}$ $1\frac{1}{2}$	117033.2 117024.9	−8.3
$2s^2\,2p^2\,({}^3P)\,3s$	${}^4P$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	97785.6 97680.3 97521.7	105.3 158.6
$3s$	${}^2P$	$\frac{1}{2}$ $1\frac{1}{2}$	94132.5 93952.5	180.0
$2s\;2p^4$	${}^2S$	$\frac{1}{2}$	87310.5	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^2\ (^3P)\ 3p$	$^2S^\circ$	$\frac{1}{2}$	*79078.7*	
$3p$	$^4D^\circ$	$\frac{1}{2}$	*76290.1*	
		$1\frac{1}{2}$	*76234.6*	55.5
		$2\frac{1}{2}$	*76143.0*	91.6
		$3\frac{1}{2}$	*76018.4*	124.6
$2s^2\ 2p^2\ (^1D)\ 3s$	^2D	$2\frac{1}{2}$	76049.6	
		$1\frac{1}{2}$	76048.6	−1.0
$2s^2\ 2p^2\ (^3P)\ 3p$	$^4P^\circ$	$\frac{1}{2}$	*74674.8*	
		$1\frac{1}{2}$	*74628.7*	46.1
		$2\frac{1}{2}$	*74536.7*	92.0
$3p$	$^2D^\circ$	$1\frac{1}{2}$	*71498.9*	
		$2\frac{1}{2}$	*71308.2*	190.7
$3p$	$^4S^\circ$	$1\frac{1}{2}$	*70859.0*	
$2s\ 2p^4$	^2P	$1\frac{1}{2}$	70435.5	
		$\frac{1}{2}$	70262.5	−173.0
$2s^2\ 2p^2\ (^3P)\ 3p$	$^2P^\circ$	$\frac{1}{2}$	*68851.2*	
		$1\frac{1}{2}$	*68791.4*	59.8
$2s^2\ 2p^2\ (^1D)\ 3p$	$^2F^\circ$	$2\frac{1}{2}$	*54297.6*	
		$3\frac{1}{2}$	*54274.0*	23.6
$3p$	$^2D^\circ$	$2\frac{1}{2}$	*53074.3*	
		$1\frac{1}{2}$	*53052.7*	−21.6
$2s^2\ 2p^2\ (^3P)\ 3d$	^4F	$1\frac{1}{2}$	51724.9	
		$2\frac{1}{2}$	51670.9	54.0
		$3\frac{1}{2}$	51593.0	77.9
		$4\frac{1}{2}$	51490.7	102.3
$2s^2\ 2p^2\ (^1D)\ 3p$	$^2P^\circ$	$\frac{1}{2}$	*50540.8*	
		$1\frac{1}{2}$	*50494.2*	46.6
$2s^2\ 2p^2\ (^3P)\ 3d$	^4P	$2\frac{1}{2}$	50558.1	
		$1\frac{1}{2}$	50485.0	−73.1
		$\frac{1}{2}$	50418.5	−66.5

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^2\ (^3P)\ 3d$	^4D	$\frac{1}{2}$	50309.4	
		$1\frac{1}{2}$	50275.0	
		$3\frac{1}{2}$	50267.1	
		$2\frac{1}{2}$	50224.7	
$3d$	^2F	$2\frac{1}{2}$	50273.4	211.6
		$3\frac{1}{2}$	50061.8	
$3d$	^2P	$1\frac{1}{2}$	49590.8	−114.0
		$\frac{1}{2}$	49476.8	
$3d$	^2D	$1\frac{1}{2}$	48618.4	52.0
		$2\frac{1}{2}$	48566.4	
$2s^2\ 2p^2\ (^3P)\ 4s$	^4P	$\frac{1}{2}$	44394.8	105.4
		$1\frac{1}{2}$	44289.4	161.4
		$2\frac{1}{2}$	44128.0	
$4s$	^2P	$\frac{1}{2}$	42692.1	187.5
		$1\frac{1}{2}$	42504.6	
$2s^2\ 2p^2\ (^3P)\ 4p$	$^4D^\circ$	$\frac{1}{2}$	*37253.4*	48.5
		$1\frac{1}{2}$	*37204.9*	86.5
		$2\frac{1}{2}$	*37118.4*	126.1
		$3\frac{1}{2}$	*36992.3*	
$(^3P)\ 4p$	$^2P^\circ$	$1\frac{1}{2}$	*34507.0*	
$2s^2\ 2p^2\ (^1D)\ 3d$	^2F	$3\frac{1}{2}$	31800.0	−103.2
		$2\frac{1}{2}$	31796.8	
$3d$	^2D	$1\frac{1}{2}$	29974.7	2.1
		$2\frac{1}{2}$	29972.6	
$3d$	^2G	$4\frac{1}{2}$	30413.2	−1.2
		$3\frac{1}{2}$	30412.0	
$3d$	^2P	$\frac{1}{2}$	29231.4	2.4
		$1\frac{1}{2}$	29229.0	
$3d$	^2S	$\frac{1}{2}$	27398.5	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p^2\,(^3P)\,4f$	$^4D°$	$3\frac{1}{2}$	*27329.5*	
		$2\frac{1}{2}$	*27207.8*	−121.7
		$1\frac{1}{2}$	*27108.9*	−98.9
		$\frac{1}{2}$	*27023.3*	−85.6
$4f$	$^4G°$	$5\frac{1}{2}$	*27043.4 ?*	
$4f$	$^4F°$	$1\frac{1}{2}$	*26937.4*	
		$2\frac{1}{2}$	*26933.3*	4.1
		$3\frac{1}{2}$	*26897.8*	35.5
		$4\frac{1}{2}$	*26884.7*	13.1
$2s^2\,2p^2\,(^3P)\,5s$	^4P	$\frac{1}{2}$	25327.2	
		$1\frac{1}{2}$	25223.0	104.2
		$2\frac{1}{2}$	25057.1	175.9
$5s$	^2P	$\frac{1}{2}$	24612.3	
		$1\frac{1}{2}$	24419.2	193.1
$2s^2\,2p^2\,(^1D)\,4s$	^2D	$2\frac{1}{2}$	23734.7	
		$1\frac{1}{2}$	23733.9	−0.8
$2s^2\,2p^2\,(^3P)\,5f$	$^4D°$	$3\frac{1}{2}$	*17376.4*	
		$2\frac{1}{2}$	*17336.8*	−39.6
$5f$	$^4F°$	$4\frac{1}{2}$	*17021.8*	
		$3\frac{1}{2}$	*17010.2*	−11.6
$5f$	1°	$1\frac{1}{2}, 2\frac{1}{2}$	*17518.2*	
$5f$	2°	$\frac{1}{2}, 1\frac{1}{2}$	*17048.5*	
$5f$	3°	$2\frac{1}{2}, 3\frac{1}{2}$	*16976.0*	
$2s^2\,2p^2\,(^1D)\,4d$	^2F	$3\frac{1}{2}$	8640.0 ?	
		$2\frac{1}{2}$	8639.6	−0.4
$4d$	^2G	$3\frac{1}{2}$	8027.5	
		$4\frac{1}{2}$	8025.6	1.9
$2s^2\,2p^2\,(^1D)\,4f$	$^2G°$	$3\frac{1}{2}, 4\frac{1}{2}$	*7338.8*	
$4f$	$^2F°$	$2\frac{1}{2}, 3\frac{1}{2}$	*7141.3*	
$4f$	$^2D°$	$1\frac{1}{2}, 2\frac{1}{2}$	*6961.8*	
$4f$	$^2H°$	$4\frac{1}{2}, 5\frac{1}{2}$	*6911.8*	
$4f$	$^2P°$	$\frac{1}{2}, 1\frac{1}{2}$	*6757.0 ?*	

O III $\quad Z = 8$

6 electrons $\quad 1s^2\ 2s^2\ 2p^2\ {}^3P_0$

Ionization potential = 54.87 volts

The classification of O III has been given by Fowler, Mihul, and Bowen. The term values here have been taken from Fowler and from Freeman. The absolute value of the lowest state has been given as 444661 cm.$^{-1}$. Intercombinations between the singlets and triplets have been found but not with the quintets which are therefore given in a separate table.

References

C. Mihul, *Comptes Rendus* **183**, 1035 (1926); **184**, 89; **184**, 874; **184**, 1055 (1927).

I. S. Bowen, *Phys. Rev.* **29**, 241 (1927).

A. Fowler, *Proc. Roy. Soc.* **A117**, 317 (1928).

L. J. Freeman, *Proc. Roy. Soc.* **A124**, 654 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\ 2p^2$	${}^3P$	0 1 2	0 116 309	116 193
$2s^2\ 2p^2$	${}^1D$	2	20276	
$2s^2\ 2p^2$	${}^1S$	0	43189	
$2s\ 2p^3$	${}^3D^\circ$	3 1, 2	*120028* *120056*	−28
$2s\ 2p^3$	${}^3P^\circ$	1, 2 0	*142384* *142400*	−16
$2s\ 2p^3$	${}^1P^\circ$	1	*210464*	
$2s\ 2p^3$	${}^3S^\circ$	1	*197089*	

(*Continued*)

Configuration		Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p$	$3s$	$^3P^\circ$	0	*267324.79*	
					118.36
			1	*267443.15*	
					256.94
			2	*267700.09*	
	$3s$	$^1P^\circ$	1	*273147.57*	
	$3p$	^1D	2	291024.12	
	$3p$	^3D	1	293932.76	
					136.34
			2	294069.10	
					220.05
			3	294289.15	
	$3p$	^3S	1	297625.00	
	$3p$	^1S	0	298382.91	
	$3p$	^3P	0	300295.71	
					82.0
			1	300377.81	
					130.54
			2	300508.35	
	$3p$	^1P	1	313868.57	
	$3d$	$^1F^\circ$	3	*324528.91*	
	$3d$	$^3F^\circ$	2	*324529.96*	
					195.79
			3	*324725.75*	
					178.16
			4	*324903.91*	
	$3d$	$^1P^\circ$	1	*324801.72*	
	$3d$	$^3D^\circ$	1	*327295.44*	
					49.24
			2	*327344.68*	
					73.72
			3	*327418.40*	
	$3d$	$^3P^\circ$	2	*329535.48*	
					−114.00
			1	*329649.48*	
					−61.45
			0	*329710.93*	
	$3d$	$^1D^\circ$	2	*332844.6*	
	$4s$	$^3P^\circ$	2	*349804*	
					−258
			1	*350062*	
					−115
			0	*350177*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\,2p$ $4s$	$^1P^\circ$	1	*352949 ?*	
$4p$	^1D	2	365791.4	
$4p$	^3D	1	366554.41	
		2	366661.51	107.10
		3	366868.54	207.03
$4p$	^3S	1	368019.70	
$4p$	^1S	0	369668 ?	
$4p$	^3P	0	370394.2	
		1	370483.2	89.0
		2	370591.7	108.5
$4p$	^1P	1	371680 ?	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\,2p^2\,(^4P)\,3s$	^5P	1	0.0	
		2	124.4	124.4
		3	285.6	161.2
$3p$	$^5D^\circ$	0	*26949.9*	
		1	*26984.7*	34.8
		2	*27053.2*	68.5
		3	*27153.3*	100.1
		4	*27280.6*	127.3
$3p$	$^5P^\circ$	1	*29960.5*	
		2	*30017.7*	57.2
		3	*30118.9*	101.2
$3p$	$^5S^\circ$	2	*37501.8*	
$3d$	^5F	1	55950.5	
		2	55989.2	38.7
		3	56046.8	57.6
		4	56122.5	75.7
		5	56214.6	92.1

O IV $\qquad Z = 8$

5 electrons $\qquad 1s^2\, 2s^2\, 2p\ {}^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 77 volts

Classification is given according to Freeman and Bowen. As no intercombinations are found, the quartets and doublets are given in separate tables. The two quartets found by Bowen from far ultra-violet observations have not yet been connected with the other terms and are also given separately. Freeman gives the absolute value of $2s\,2p\,3s\ {}^4P_{\frac{1}{2}}^{\circ}$ as about 623500 cm.$^{-1}$ with respect to $2s\,2p\ {}^3P^{\circ}$ of O V.

References

I. S. Bowen, *Phys. Rev.* **29**, 231 (1927).
L. J. Freeman, *Proc. Roy. Soc.* **A127**, 330 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s^2\, 2p$	$^2P^{\circ}$	$\frac{1}{2}$	*0*	387
		$1\frac{1}{2}$	*387*	
$2s\ 2p^2$	^2D	$2\frac{1}{2}$	126936.4	−12.9
		$1\frac{1}{2}$	126949.3	
	^2S	$\frac{1}{2}$	164368	
	^2P	$\frac{1}{2}$	180482	246
		$1\frac{1}{2}$	180728	
$2p^3$	$^2D^{\circ}$	$2\frac{1}{2}$	*255158*	−27
		$1\frac{1}{2}$	*255185*	
	$^2P^{\circ}$	$\frac{1}{2}, 1\frac{1}{2}$	*289024*	
$2s^2\, 3s$	^2S	$\frac{1}{2}$	357713.0	
$2s^2\, 3p$	$^2P^{\circ}$	$\frac{1}{2}$	*390259.4*	87.0
		$1\frac{1}{2}$	*390346.4*	
$2s^2\, 3d$	^2D	$1\frac{1}{2}$	419631.8	16.6
		$2\frac{1}{2}$	419648.4	

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 3p\ 3s$	$^4P^\circ$	½	*0*	
		1½	*135.1*	135.1
		2½	*382.0*	246.9
$2s\ 2p\ 3p$	^4D	½	29486.9	
		1½	29565.7	78.8
		2½	29701.2	135.5
		3½	29910.9	209.7
	^4S	1½	35629.3	
	^4P	½	39999.2	
		1½	40093.7	94.5
		2½	40222.8	129.1
$2s\ 2p\ 3d$	$^4F^\circ$	1½	*56319.0*	
		2½	*56397.8*	78.8
		3½	*56510.2*	112.4
		4½	*56664.3*	154.1
	$^4D^\circ$	½	*60917.9*	
		1½	*60946.8*	28.9
		2½	*60993.5*	46.7
		3½	*61058.1*	64.6
	$^4P^\circ$	2½	*65246.0*	
		1½	*65359.4*	−113.4
		½	*65438.6*	−79.2

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s\ 2p^2$	^4P	½	0	
		1½	132	132
		2½	317	185
$2p^3$	$^4S^\circ$	1½	*160100*	

O V $Z = 8$

4 electrons $1s^2\ 2s^2\ {}^1S_0$

Ionization potential = 113 volts

Bowen has classified some of the lines found by Edlén and Ericson, and added it to the previous work of Bowen and Millikan. The singlets are from the work of Edlén who gives the absolute value of the lowest state as 917439 cm.$^{-1}$. No intercombinations have been found.

References

I. S. Bowen and R. A. Millikan, *Phys. Rev.* **26,** 150 (1925).
B. Edlén, *Nature* **127,** 744 (1931).
I. S. Bowen, unpublished material.

Configuration	Symbol	J	Term value
$2s^2$	^1S	0	0
$2s\ 2p$	$^1P°$	1	*158795*
$2p^2$	^1D	2	231719
$2p^2$	^1S	0	287907
$2s\ 3p$	$^1P°$	1	*580828*

Configuration	Symbol	J	Term value	
$2s\ 2p$	$^3P°$	0 1 2	*0* *135* *441*	135 306
$2p^2$	^3P	0 1 2	131518 131674 131941	156 267

(*Concluded*)

Configuration	Symbol	J	Term value	
$2s\ 3s$	^3S	1	465120	
$2s\ 3d$	^3D	1, 2, 3	518840	
$2s\ 4d$	^3D	1, 2, 3	660260	
$2s\ 5d$	^3D	1, 2, 3	724330	
$2s\ 6d$	^3D	1, 2, 3	759120	

O VI $Z = 8$

3 electrons $1s^2\ 2s\ ^2S_{\frac{1}{2}}$

Ionization potential = 137.48 volts

This classification has been given by Edlén and Ericson.

Reference

B. Edlén and A. Ericson, *Zeits. f. Physik* **64**, 64 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$2s$	^2S	$\frac{1}{2}$	1114206	
$2p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*1017822* *1017294*	528
$3s$	^2S	$\frac{1}{2}$	474124	
$3p$	$^2P^\circ$	$\frac{1}{2}$, $1\frac{1}{2}$	*447939*	
$3d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	439506	
$4p$	$^2P^\circ$	$\frac{1}{2}$, $1\frac{1}{2}$	*250946*	
$4d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	246964	
$5d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	158747	

76 electrons

Only these six low even levels have been reported up to the present.

Reference

W. F. Meggers and O. Laporte, *Phys. Rev.* **28**, 642 (1926).

Symbol	Term value
1	0.0
2	3931.0
3	4159.5
4	5144.0
5	8732.8
6	11020.5

P I $\qquad Z = 15$

15 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^3\;{}^4S_{1\frac{1}{2}}$

McLennan and McLay have found several of the low levels of the arc spectrum of phosphorus. They have found no intercombinations between the quartet and doublet systems and so they are listed separately.

References

J. C. McLennan and A. B. McLay, *Trans. Roy. Soc. Can.* **21**, 592 (1925). Levels given here.

D. G. Dhavale, *Nature*, **123**, 799 (1929). Uncertain and sketchy additions.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^3$	${}^4S^\circ$	$1\frac{1}{2}$	*0*	
$3s^2\,3p^2\,({}^3P)\,4s$	${}^4P$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	55944 56095 56344	151 249

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^3$	${}^2D^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$	*0* *14.6*	14.6
$3s^2\,3p^3$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*7362.2* *7387.5*	25.3
$3s^2\,3p^2\,({}^3P)\,4s$	${}^2P$	$\frac{1}{2}$ $1\frac{1}{2}$	46516.1 46813.8	297.7
—	1	$1\frac{1}{2}$ or $2\frac{1}{2}$	53796.3	
	2 3	$1\frac{1}{2}$ $\frac{1}{2}$	56196.1 56770.2	${}^2P$?

P II $\qquad$ $Z = 15$

14 electrons $\qquad$ $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^2\ {}^3P_0$

First ionization potential = 19.8 volts

The classification has been taken from the work of Bowen. The absolute value of the lowest state $3p^2\ {}^3P_0$ is given as 160497.7 cm.$^{-1}$ referred to $3p\ {}^2P_{\frac{1}{2}}^{\circ}$ of P III.

Reference

I. S. Bowen, *Phys. Rev.* **29**, 510 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\, 3p^2$	^3P	0	0	
		1	165.3	165.3
		2	469.9	304.6
$3s^2\, 3p\ 3d$	$^3D^{\circ}$	1	*65251.7*	
		2	*65272.0*	20.3
		3	*65306.7*	34.7
$3s^2\, 3p\ 3d$	$^3P^{\circ}$	2	*76763.8*	
		1	*76812.2*	−48.4
		0	*76823.0*	−10.8
$3s^2\, 3p\ 4s$	$^3P^{\circ}$	0	*86597.7*	
		1	*86744.1*	146.4
		2	*87124.8*	380.7
$3s^2\, 3p\ 4p$	^3D	1	103165.7	
		2	103339.2	173.5
		3	103667.9	328.7
$3s\ 3p^3$	$^3D^{\circ}$	1	*104054.6*	
		2	*104103.0*	48.4
		3	*104196.4*	93.4
$3s^2\, 3p\ 4p$	^3P	0	105224.5	
		1	105302.6	78.1
		2	105549.9	247.3

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p\;4p$	^3S	1	106001.5	
$3s\;3p^3$	$^3P^\circ$	0	—	
		1	*110253.9*	38.6
		2	*110292.5*	
$3s^2\,3p\;5s$	$^3P^\circ$	0	*123344.4*	111.3
		1	*123455.7*	435.5
		2	*123891.2*	
$3s^2\,3p\;4d$	1°	?	*127367.7*	
	2°	?	*127599.8*	
	3°	?	*127889.3*	
	4°	?	*127934.7*	
	5°	?	*127950.1*	

P III $\quad Z = 15$

13 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p\ ^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 30.0 volts

The classification is given by Bowen and Millikan with the higher terms as taken from Saltmarsh. These higher terms are connected to the lower terms only by the combination $3s^2\,4p$–$3s^2\,5d$. The absolute value of the lowest state is given as 243332.1 cm.$^{-1}$ referred to $3s^2\ ^1S$ of P IV. The quartets have not been connected with the other terms.

References

R. A. Millikan and I. S. Bowen, *Phys. Rev.* **25**, 600 (1925).
M. O. Saltmarsh, *Proc. Roy. Soc.* **A108**, 332 (1925).
I. S. Bowen, *Phys. Rev.* **31**, 34 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*0* *559.6*	559.6
$3s\ 3p^2$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	74916.4 74945.8	29.4
$3s\ 3p^2$	^2S	$\frac{1}{2}$	100197.0	
$3s\ 3p^2$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	109035.4 109410.6	375.2
$3s^2\,3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	116870.7 116882.1	11.4
$3s^2\,4s$	^2S	$\frac{1}{2}$	117834.3	
$3s^2\,4p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*141374.3* *141510.9*	136.6
$3s^2\,4d$	^2D	$1\frac{1}{2}$, $2\frac{1}{2}$	172427.6	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,5s$	^2S	$\frac{1}{2}$	176039.3	
$3s^2\,4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*178653.3*	
$3s^2\,5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*185887* *185939*	52
$3s^2\,5d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	200745	
$3s^2\,6s$	^2S	$\frac{1}{2}$	202482	
$3s^2\,6d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	213970	
$3s^2\,7s$	^2S	$\frac{1}{2}$	216216	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\,3p^2$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	0 205.0 531.5	205.0 326.5
$3p^3$	$^4S^\circ$	$1\frac{1}{2}$	*102793.1*	

P IV $Z = 15$

12 electrons $1s^2\,2s^2\,2p^6\,3s^2\ {}^1S_0$

The classification is taken from the work of Bowen and Millikan. One strong line has been identified as the main singlet combination. No intercombinations between singlets and triplets have been found.

Reference

I. S. Bowen and R. A. Millikan, *Phys. Rev.* **25**, 591 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\,3p$	$^3P^\circ$	0	*0.0*	
		1	*128.6*	128.6
		2	*696.5*	567.9
$3p^2$	^3P	0	97021	
		1	97264	243
		2	97735	470
$3s\,3d$	^3D	1, 2, 3	121476	
$3s\,4s$	^3S	1	158974	
$3s\,4p$	$^3P^\circ$	0	*188629*	
		1	*188688*	59
		2	*188836*	148
$3s\,4d$	^3D	1	225317	
		2	225323	6
		3	225331	8
$3s\,5s$	^3S	1	241182	

Configuration	Symbol	J	Term value
$3s^2$	^1S	0	0
$3s\,3p$	$^1P^\circ$	1	*105190*

P V $\quad Z = 15$

11 electrons $\quad 1s^2\,2s^2\,2p^6\,3s\;{}^2S_{\frac{1}{2}}$

First ionization potential = 64.70 volts

The classification has been given by Millikan and Bowen.

Reference

R. A. Millikan and I. S. Bowen, *Phys. Rev.* **25**, 295 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s$	${}^2S$	$\frac{1}{2}$	524491.2	
$3p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*435841.8* *435047.0*	794.8
$3d$	${}^2D$	$1\frac{1}{2}, 2\frac{1}{2}$	320295.0	
$4s$	${}^2S$	$\frac{1}{2}$	251540.7	
$4p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*220339.0* *220055.1*	283.9
$4d$	${}^2D$	$1\frac{1}{2}, 2\frac{1}{2}$	179101.1	
$4f$	${}^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*171909.4*	
$5s$	${}^2S$	$\frac{1}{2}$	147858.7	
$5f$	${}^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*110036.5*	
$5g$	${}^2G$	$3\frac{1}{2}, 4\frac{1}{2}$	109818.4	
$6g$	${}^2G$	$3\frac{1}{2}, 4\frac{1}{2}$	76278.5	
$6h$	${}^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*76255.2*	

Pb I $Z = 82$

82 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p^2\ {}^3P_0$

Ionization potential = 7.38 volts

These terms were obtained from a paper by Gieseler and Grotrian together with unpublished infra-red data kindly given to us by Dr. Randall.

Gieseler and Grotrian give a series of terms which combine with the levels of the p^2 configuration and which they believed to be pf states. These terms have been omitted here. The absolute values of all terms are given with respect to $6p\ {}^2P_{\frac{1}{2}}$ of Pb II.

The low terms are given in the first table; all terms are given in the other tables in series form.

References

H. Gieseler and W. Grotrian, *Zeits. f. Physik* **34**, 374 (1925); and **39**, 371 (1926).

H. M. Randall, unpublished data.

E. Back, *Zeits. f. Physik* **37**, 193 (1926); and **43**, 309 (1927). Zeeman effect.

Configuration	Symbol	J	Term value		g-values
$6p^2$	^3P	0	59821		
		1	52004		1.501
		2	49173		1.268
$6p^2$	^1D	2	38365		1.230
$6p^2$	^1S	0	30365		
$6p\ (^2P_{\frac{1}{2}})\ 7s$	1°	0	*24863*	$^3P_0$	
	2°	1	*24536*	$^3P_1$	1.349
$6p\ (^2P_{\frac{1}{2}})\ 7p$	1	1	16906		
	2	0	15424		
	3	1	15149		
	4	2	15014		
$6p\ (^2P_{\frac{1}{2}})\ 6d$	1°	2	*14380*		0.796
	2°	2	*13762*		1.247
	3°	1	*13754*		0.864
	4°	3	*13494.5*		1.116

SERIES

$6s^2\,6p^2$				
$^3P_0$	$^3P_1$	$^3P_2$	$^1D_2$	$^1S_0$
59821	52004	49173	38365	30365

m	$6s^2\,6p\,(^2P_{\frac{1}{2}})\,ms$		$6s^2\,6p\,(^2P_{1\frac{1}{2}})\,ms$	
	$1_0°\,(^3P_0°)$	$2_1°\,(^3P_1°)$	$3_2°\,(^3P_2°)$	$4_2°\,(^1P_1°)$
7	*24863*	*24536*	*11634**	*10383***
8	*11096*	*11136****	*−8820 ?*	
9	*6348*	*6313*		
10	*4112*	*4103*		
11		*2883*		
12		*2134*		
13		*1644*		
14		*1305*		
15		*1060*		
16		*878*		
17		*741*		

$6s^2\,6p\,(^2P_{\frac{1}{2}})\,mp$				
m	1_1	2_0	3_1	4_2
7	16906	15424	15149	15014
8	8503	8037	7906	
9	5170	4961	4895	
10		3378	3348	
11		2444	2394	
12		1851		

m	$6s^2\,6p\,(^2P_{\frac{1}{2}})\,md$				$6p\,(^2P_{1\frac{1}{2}})\,md$
	$1_2°$	$2_2°$	$3_1°$	$4_3°$	$5_2°$
6	*14380*	*13762*	*13754*	*13494.5*	*1305 ?*
7	*7512*		*7323*	*7721*	
8	*4740*		*4666*	*4820*	
9	*3261*		*3219*	*3297*	
10	*2379*		*2353*	*2399*	
11	*1811*		*1793*	*1826*	
12	*1427*		*1412*	*1442*	
13			*1142*	*1155*	
14			*944*	—	
15			*794*	*767*	
16			*655*	—	
17			*574*	*565*	
18			*503*		
19			*442*		
20			*391*		

$6p\,(^2P_{\frac{1}{2}})\,mf$	
m	1_2
5	6973.2
6	4465.2
7	3105.1 ?

*g = 1.496
** = 1.131
*** = 1.304

Pb II $Z = 82$

81 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p\ {}^2P^{\circ}_{\frac{1}{2}}$

Ionization potential = 15.0 volts

This classification has been taken from the work of Gieseler. The $6s\ 6p^2\ {}^2D$ and $6s^2\ 6d\ {}^2D$ overlap, and the separation of these two states has perhaps little physical meaning. All ${}^2D$ and ${}^2F$ terms are inverted.

Reference

H. Gieseler, *Zeits. f. Physik* **42**, 265 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s^2\ 6p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*121256* *107186*	14070
$6s\ 6p^2$	${}^4P$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	63821 61063 51057	2758
$6s^2\ 7s$	${}^2S$	$\frac{1}{2}$	61818	
$6s\ 6p^2$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	55116 47336	7780
$6s^2\ 6d$	${}^2D$	$2\frac{1}{2}$ $1\frac{1}{2}$	52277 51505	−772
$6s^2\ 7p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*46809* *43996*	2813
$6s^2\ 8s$	${}^2S$	$\frac{1}{2}$	32270	
$6s^2\ 7d$	${}^2D$	$2\frac{1}{2}$ $1\frac{1}{2}$	28763 28537	−226
$6s^2\ 5f$	${}^2F^{\circ}$	$3\frac{1}{2}$ $2\frac{1}{2}$	*28726* *28711*	−15

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s^2\ 8p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*25929* *25181*	748
$6s^2\ 9s$	^2S	$\frac{1}{2}$	19922	
$6f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*18374* *18361*	−13
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	17687	
$10s$	^2S	$\frac{1}{2}$	13516	
$7f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*12710* *12701*	−9
$6g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	12272	
$8f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*9298* *9292*	−6
$7g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	9010	
$9f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*7095* *7091*	−4
$8g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	6894	
$9g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	5444	
$10g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	4406	
$11g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	3640	

Pb III $Z = 82$

80 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ {}^1S_0$

Ionization potential = 31.9 volts

The classification is given according to S. Smith. The lowest term is estimated to be 258778 cm.$^{-1}$. The configurations assigned to the ^1D terms are not certain.

Reference

S. Smith, *Phys. Rev.* **34**, 393 (1929); **36**, 1 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s^2$	^1S	0	0	
$6s\ 6p$	$^3P^\circ$	0	*60395*	
				3993
		1	*64388*	
				14595
		2	*78983*	
$6s\ 6p$	$^1P^\circ$	1	*95341*	
$6s\ 7s$	^3S	1	150078	
$6s\ 6d$	^1D	2	151882	
$6s\ 7s$	^1S	0	153780	
$6p^2$	^3P	1	155431 ?	
$6s\ 6d$	^3D	1	157441	
				481
		2	157922	
				1031
		3	158953	
$6p^2$	^1D	2	164815	
$6s\ 7p$	$^3P^\circ$	0	*170912*	
				164
		1	*171076*	
				4941
		2	*176017*	
$6s\ 7p$	$^1P^\circ$	1	*177178*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s\ 5f$	$^3F^\circ$	3	*189780*	
		2	*190283*	
		4	*190424*	
$6s\ 5f$	$^1F^\circ$	3	*190898*	
$6s\ 8s$	^3S	1	197887	
$6s\ 7d$	^1D	2	199396	
$6s\ 7d$	^3D	1	201392	
				199
		2	201591	
				450
		3	202041	

79 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s\ {}^2S_{\frac{1}{2}}$

Two probable classifications are proposed by Smith. Note that in the second classification given here the $6d\ {}^2D$ is inverted.

Reference

S. Smith, *Phys. Rev.* **36**, 1 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$	Term value	$\Delta\nu$
$6s$	${}^2S$	$\frac{1}{2}$	0		0	
$6p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*76155* *97218*	21063	*76155* *97218*	21063
$6d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	184556 186816	2260	188418 186816	−2398
$7s$	${}^2S$	$\frac{1}{2}$	185100		188964	
$7p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*209786* *217849*	8063	*213648* *221713*	8065
$7d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	249630 250233	603	253494 254097	603

78 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ {}^1S_0$

These levels are taken from the work of Mack. Of the $6p$ terms only the six built upon the low $d^9\ {}^2D_{2\frac{1}{2}}$ of the ion have been found.

Reference

J. E. Mack, *Phys. Rev.* **34**, 17 (1929).

Configuration	Symbol	J	Term value	
$5d^9\ ({}^2D_{2\frac{1}{2}})\ 6s$	1	3	0	${}^3D$
	2	2	3944	${}^3D$
$({}^2D_{1\frac{1}{2}})\ 6s$	3	1	—	${}^3D$
	4	2	25234	${}^1D$
$5d^9\ ({}^2D_{2\frac{1}{2}})\ 6p$	1°	2	*84043*	
	2°	3	*86370*	
	3°	4	*110296*	
	4°	2	*113130*	
	5°	3	*115744*	
	6°	1	*117075 ?*	

Pd I $Z = 46$

46 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\;{}^1S_0$

Ionization potential = 8.3 volts

This classification is taken from the work of Shenstone, whose multiplet designation and g-values are given in the last column. According to Shenstone the term 7_1 cannot be accounted for by the theory, all terms in that region predicted by the theory are found, but this one is superfluous. In its combinations this term is closely connected with the $4d^9\,({}^2D_{2\frac{1}{2}})\,5d$ group.

Reference

A. G. Shenstone, *Phys. Rev.* **36**, 669 (1930).

Configuration	Symbol	J	Term value	Remarks	g-values
$4d^{10}$	${}^1S$	0	0.0		
$4d^9\,({}^2D_{2\frac{1}{2}})\,5s$	1	3	6564.0	${}^3D$	1.33
	2	2	7755.0	${}^3D$	1.17
$({}^2D_{1\frac{1}{2}})\,5s$	3	1	10093.9	${}^3D$	0.50
	4	2	11721.7	${}^1D$	1.00
$4d^8\,5s^2$	1	4	25101.1	${}^3F$	
	2	3	28213.5	${}^3F$	
	3	2	29711.0	${}^3F$	
$4d^9\,({}^2D_{2\frac{1}{2}})\,5p$	1°	2	*34068.8*	${}^3P$	1.50
	2°	3	*35451.3*	${}^3F$	1.08
	3°	4	*35927.8*	${}^3F$	1.25
	4°	1	*36180.5*	${}^3P$	1.42
	5°	2	*36975.8*	${}^3D$	1.03
	6°	3	*37393.5*	${}^3D$	1.33
$4d^8\,5s^2$	4	2	37952.0	${}^3P$	

(*Continued*)

Configuration	Symbol	J	Term value	Remarks	g-values
$4d^9\ (^2D_{1\frac{1}{2}})\ 5p$	7°	0	*38088.0*	^3P	
	8°	2	*38811.7*	^3F	0.72
	9°	3	*39858.1*	^1F	1.08
	10°	1	*40368.6*	^3D	0.82
	11°	2	*40771.3*	^1D	1.14
	12°	1	*40838.7*	^1P	0.76
$4d^9\ (^2D_{2\frac{1}{2}})\ 6s$	1	3	48804.2	^3D	
	2	2	49019.5	^3D	
—	1°	3	*50910.4*	$4d^8\ 5s\ 5p\ ^5D$?	1.47 ?
$4d^9\ (^2D_{1\frac{1}{2}})\ 6s$	3	1	52336.3	^3D	
	4	2	52487.7	^1D	
—	2°	3	*52457.0*		1.26 ?
	3°	3	*53761.6*	^3F ?	
	4°	3	*54335.9*		
$4d^9\ (^2D_{2\frac{1}{2}})\ 5d$	1	1	54574.1	^3S	
—	5°	4	*54600.2 ?*		
	6°	3	*54673.2*		1.29 ?
$4d^9\ (^2D_{2\frac{1}{2}})\ 5d$	2	5	54806.1	^3G	
	3	4	54811.3	^3G	
	4	2	54820.6	^3P	
	5	1	54822.7	^3P	
—	7	1	54825.9	"k_1"	
$4d^9\ (^2D_{2\frac{1}{2}})\ 5d$	6	3	54947.7	^3D	
	7	2	54998.5	^3D	
	8	3	55012.2	^3F	
	9	4	55025.2	^3F	
	10	0	55373.0	^3P	
—	8°	2	*55634.1*		0.92 ?
	9°	2	*56335.9*		
	10°	4	*56544.6*		1.06
	11°	3	*56910.9*	^3D	1.33
	12°	3	*57255.0*		
	13°	2	*57565.2*		
	14°	2	*57926.2 ?*		

(*Continued*)

Configuration	Symbol	J	Term value	Remarks	g-values
$4d^9\ (^2D_{2\frac{1}{2}})\ 7s$	1	3	58064.1	^3D	
—	15°	2	*58103.7*		
$4d^9\ (^2D_{2\frac{1}{2}})\ 7s$	2	2	58138.3	^3D	
$4d^9\ (^2D_{1\frac{1}{2}})\ 5d$	11	1	58195.3	^1P	
—	16°	4	*58316.8*	$4d^8\ 5s\ 5p\ ^3F$?	1.25
$4d^9\ (^2D_{1\frac{1}{2}})\ 5d$	12	3	58348.9	^3G	
	13	4	58387.8	^1G	
—	17°	3	*58389.8*		
$4d^9\ (^2D_{1\frac{1}{2}})\ 5d$	14	1	58408.1	^3D	0.91 ?
—	18°	2	*58415.1*		
$4d^9\ (^2D_{1\frac{1}{2}})\ 5d$	15	2	58448.5	^1D	
	16	2	58555.8	^3F	
	17	3	58561.7	^1F	
	18	0	58681.3	^1S	
—	19°	3	*59143.1*		1.04 ?
	20°	1	*59588.4*		
	21°	2	*59731.2*		
$4d^9\ (^2D_{2\frac{1}{2}})\ 6d$	1	1	60225.8 ?	^3S	
	2	5	60315.5	^3G ?	
	3	4	60318.2	^3G	
	4	2	60322.0	^3P	
	5	1	60323.4	^3P	
	6	3	60370.4	^3D	
	7	3	60397.9	^3F	
	8	2	60397.9	^3D	
	9	4	60404.0	^3F	
	22°	3	*60722.6*	$4d^8\ 5s\ 5p$? ^3F	1.20 ?
	23°	1	*60729.8*		
$4d^9\ (^2D_{1\frac{1}{2}})\ 7s$	3	1	61602.8	^3D	
	4	2	61638.6	^1D	

(*Concluded*)

Configuration	Symbol	J	Term value	Remarks	g-values
$4d^9\ (^2D_{2\frac{1}{2}})\ 8s$	1	3	61736.2	^3D	
—	24°	3	*62316.3*		1.08
$4d^9\ (^2D_{2\frac{1}{2}})\ 9s$	1	3	63571.7 ?	^3D	
$4d^9\ (^2D_{1\frac{1}{2}})\ 6d$	10	3	63853.0	^3G	
	11	4	63872.7	^1G	
	12	1	63896.3	^3D	
	13	2	63937.4	^3F	
	14	3	63939.8	^1F	

Pd II $Z = 46$

45 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^9\ {}^2D_{2\frac{1}{2}}$

Ionization potential = 19.8 volts

These terms have been taken from the work of Shenstone and of Blair. Shenstone has also made an extensive study of the Zeeman effect. Those g-values which differ from Landé's values are given in the last column. In this spectrum the division into multiplets is for many levels quite uncertain.

The relative term value of the lowest state is not known with accuracy and for that reason Shenstone put the lowest ${}^4F$ level equal to zero.

The absolute value of the lowest state is about 160600 cm.$^{-1}$ with respect to $4d^8\ {}^3F_4$ of Pd III.

References

A. G. Shenstone, *Phys. Rev.* **32**, 30 (1928).
H. A. Blair, *Phys. Rev.* **36**, 173 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$	g-values
$4d^9$	${}^2D$	$2\frac{1}{2}$	0	−3539	
		$1\frac{1}{2}$	3539		
$4d^8\ ({}^3F)\ 5s$	${}^4F$	$4\frac{1}{2}$	25081.0	−2013.3	
		$3\frac{1}{2}$	27094.3	−1832.7	
		$2\frac{1}{2}$	28927.0	−1018.6	
		$1\frac{1}{2}$	29945.6		
$4d^8\ ({}^3F)\ 5s$	${}^2F$	$3\frac{1}{2}$	32277.9	−2144.1	1.20
		$2\frac{1}{2}$	34422.0		1.10
$4d^8\ ({}^3P)\ 5s$	${}^4P$	$2\frac{1}{2}$	36281.5	−1083.5	1.36
		$1\frac{1}{2}$	37365.0	−1137.4	1.47
		$\frac{1}{2}$	38502.4		2.73
$4d^8\ ({}^1D)\ 5s$	${}^2D$	$1\frac{1}{2}$	39571.1	1627.2	1.20
		$2\frac{1}{2}$	41198.3		1.30
$4d^8\ ({}^3P)\ 5s$	${}^2P$	$1\frac{1}{2}$	43647.8	−292.0	1.25
		$\frac{1}{2}$	43939.8		.69

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	g-values
$4d^8\ (^1G)\ 5s$	^2G	$4\frac{1}{2}$	44505.7	−108.2	
		$3\frac{1}{2}$	44613.9		
$4d^8\ (^3F)\ 5p$	$^4D^\circ$	$3\frac{1}{2}$	*65247.0*	−2715.2	
		$2\frac{1}{2}$	*67962.2*	−2157.6	
		$1\frac{1}{2}$	*70119.8*	−1059.1	
		$\frac{1}{2}$	*71178.9*		
$4d^8\ (^3F)\ 5p$	$^4G^\circ$	$4\frac{1}{2}$	*67299.0*		
		$5\frac{1}{2}$	*68611.5*		
		$3\frac{1}{2}$	*69610.2*		
		$2\frac{1}{2}$	*71069.5*		.66
$4d^8\ (^3F)\ 5p$	$^4F^\circ$	$4\frac{1}{2}$	*69878.4*		
		$3\frac{1}{2}$	*71244.7*		1.18
		$1\frac{1}{2}$	*72348.0*		.68
		$2\frac{1}{2}$	*73112.4*		
$4d^8\ (^3F)\ 5p$	$^2G^\circ$	$4\frac{1}{2}$	*72285.0*	−2033.7	
		$3\frac{1}{2}$	*74318.7*		
$4d^8\ (^3F)\ 5p$	$^2D^\circ$	$2\frac{1}{2}$	*72732.6*	−2365.4	1.05
		$1\frac{1}{2}$	*75098.0*		.86
$4d^8\ (^3F)\ 5p$	$^2F^\circ$	$3\frac{1}{2}$	*73327.5*	−2426.1	1.16
		$2\frac{1}{2}$	*75753.6*		
$4d^8\ (^3P)\ 5p$	$^4P^\circ$	$1\frac{1}{2}$	*76754.5*		1.33
		$2\frac{1}{2}$	*76767.4*		1.36
		$\frac{1}{2}$	*76807.4*		2.25
$4d^8\ (^1D)\ 5p$	$^2F^\circ$	$2\frac{1}{2}$	*78765.3*	942.7	1.10
		$3\frac{1}{2}$	*79708.0*		1.26
$4d^8\ (^1D)\ 5p$	$^2P^\circ$	$\frac{1}{2}$	*79612.4*	1343.7	1.16
		$1\frac{1}{2}$	*80956.1*		
$4d^8\ (^1D)\ 5p$	$^2D^\circ$	$1\frac{1}{2}$	*81557.2*	499.8	1.26
		$2\frac{1}{2}$	*82057.0*		1.25
$4d^8\ (^3P)\ 5p$	$^4D^\circ$	$\frac{1}{2}$	*81805.0*	606.3	.07
		$1\frac{1}{2}$	*82333.7*	116.3	1.22
		$2\frac{1}{2}$	*82450.0*	528.7	1.30
		$3\frac{1}{2}$	*83056.3*		1.29

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	g-values
$4d^8\ (^1G)\ 5p$	$^2H°$	$4\frac{1}{2}$	83789.7	1803.2	
		$5\frac{1}{2}$	85592.9		
$4d^8\ (^3P)\ 5p$	$^2D°$	$2\frac{1}{2}$	83802.5	−569.8	
		$1\frac{1}{2}$	84372.3		
$4d^8\ (^3P)\ 5p$	$^2S°$	$\frac{1}{2}$	85070.7		1.88
$4d^8\ (^3P)\ 5p$	$^2P°$	$1\frac{1}{2}$	85151.0	−2887.1	1.50
		$\frac{1}{2}$	88038.1		.70
$4d^8\ (^1G)\ 5p$	$^2F°$	$3\frac{1}{2}$	86043.1	−1077.3	
		$2\frac{1}{2}$	87120.4		
$4d^8\ (^3P)\ 5p$	$^4S°$	$1\frac{1}{2}$	86279.6		
$4d^8\ (^1G)\ 5p$	$^2G°$	$3\frac{1}{2}$	89682.5	299.9	
		$4\frac{1}{2}$	89982.4		
$4d^8\ (^3F)\ 6s$	^4F	$4\frac{1}{2}$	104616.0	−692.2	
		$3\frac{1}{2}$	105308.2	−2838.8	
		$2\frac{1}{2}$	108147.0	−1183.0	
		$1\frac{1}{2}$	109330.0		
$4d^8\ (^3F)\ 6s$	^2F	$3\frac{1}{2}$	108146.0	−1782.5	
		$2\frac{1}{2}$	109928.5		
—	1	$3\frac{1}{2}$	110204.5	$d^8\ (^3F)\ 5d\ ^4D$	
	2	$5\frac{1}{2}$	110624.5	$(^3F)\ 5d\ ^4H$	
	3	$2\frac{1}{2}$	110821.9	$(^3F)\ 5d\ ^4D$	
	4	$4\frac{1}{2}$	110886.6	$(^3F)\ 5d\ ^4F$	
	5	$5\frac{1}{2}$	110910.3	$(^3F)\ 5d\ ^4G$	
	6	$6\frac{1}{2}$	110986.8	$(^3F)\ 5d\ ^4H$	
	7	$3\frac{1}{2}$	111090.3	$(^3F)\ 5d\ ^4F$	
	8	$4\frac{1}{2}$	111247.0	$(^3F)\ 5d\ ^4G$	
	9	$3\frac{1}{2}$	113835.7	$(^3F)\ 5d\ ^4G$	
	10	$3\frac{1}{2}$	114001.4		
	11	$2\frac{1}{2}$	114228.2	$(^3F)\ 5d\ ^4F$	
	12	$3\frac{1}{2}$	114241.0	$(^3F)\ 5d\ ^2F$?	
	13	$2\frac{1}{2}$	114647.6	$(^3F)\ 5d$	
	14	$2\frac{1}{2}$	114940.2	$(^3F)\ 5d$	
	15	$\frac{1}{2}$	115426.9	$(^3F)\ 5d$	
	16	$1\frac{1}{2}$	115449.7	$(^3F)\ 5d\ ^4F_{1\frac{1}{2}}$	
	17	$3\frac{1}{2}$	115551.5	$(^3F)\ 5d$	
	18	$3\frac{1}{2}$	115771.2	$(^3F)\ 5d$	
	19	$2\frac{1}{2}$	116511.6	$(^3P)\ 6s\ ^4P$	
	20	$2\frac{1}{2}$	117149.7	$(^3F)\ 5d$	
	21	$1\frac{1}{2}$	117332.1	$(^3F)\ 5d$	

(*Concluded*)

Configuration	Symbol	J	Term value	
—	22	$1\frac{1}{2}$	118144.6	$(^3P)\ 6s\ ^4P$?
	23	$2\frac{1}{2}$	118648.5	$(^3F)\ 5d$
	24	$1\frac{1}{2}$	118781.7	$(^1D)\ 6s\ ^2D$
	25	$\frac{1}{2}$	118918.4	$(^3P)\ 6s\ ^4P$
	26	$\frac{1}{2}$	119080.6	$(^3P)\ 6s\ ^2P$?
	27	$2\frac{1}{2}$	119394.6	$(^1D)\ 6s\ ^2D$
	28	$1\frac{1}{2}$	119743.6	$(^3P)\ 6s\ ^2P$
	29	$4\frac{1}{2}$	122706.0	$(^1G)\ 6s\ ^2G$
	30	$3\frac{1}{2}$	122718.5	$(^1G)\ 6s\ ^2G$
	31	$1\frac{1}{2}$	123755.0	$(^1D)\ 5d$
	32	$1\frac{1}{2}$	123866.1	$(^1D)\ 5d$
	33	$2\frac{1}{2}$	124149.6	$(^1D)\ 5d$
	34	$2\frac{1}{2}$	124280.3	$(^1D)\ 5d$
	35	—	124930.0	$(^1D)\ 5d$
	36	$2\frac{1}{2}$	128385.2	$(^1G)\ 5d\ ^2D$
	37	$3\frac{1}{2}$	128623.6	$(^1G)\ 5d\ ^2F$
	38	$2\frac{1}{2}$	128664.5	$(^1G)\ 5d\ ^2F$
	39	$4\frac{1}{2}$	129309.3	$(^1G)\ 5d\ ^2G$
	40	$3\frac{1}{2}$	129382.5	$(^1G)\ 5d\ ^2G$

78 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^9\ (^2D_{2\frac{1}{2}})\ 6s\ ^3D_3$

Ionization potential = 8.9 volts

This classification has been taken from the work of Livingood, who has also studied the Zeeman effect. The electron configurations can be given for only the low even terms and for the $5d^9\ ms$ levels. The odd terms arise from the $5d^9\ 6p$ and $5d^8\ 6s\ 6p$ configurations.

Reference

J. J. Livingood, *Phys. Rev.* **34,** 185 (1929).

Configuration	Symbol	J	Term value		g-value
$5d^9\ (^2D_{2\frac{1}{2}})\ 6s$	1	3	0.0	^3D	1.33
	2	2	775.9	^3D	1.01
$5d^8\ 6s^2$	1	4	823.9		1.25
$5d^{10}$	^1S	0	6140.0		
$5d^8\ 6s^2$	2	2	6567.5		1.12
	3	3	10116.8		1.08
$5d^9\ (^2D_{1\frac{1}{2}})\ 6s$	3	1	10132.0	^3D	0.50
	4	2	13496.3	^1D	1.17
$5d^8\ 6s^2$	4	2	15501.8		.92
	5	1	18566.5		1.50
	6	4	21967.1		1.+?
	7	2	26638.6		0.97
—	1°	4	*30157.0*		1.46
	2°	2	*32620.0*		1.39
	3°	5	*33680.5*		1.32
	4°	3	*34122.1*		1.21
	5°	3	*35321.7*		1.33

(*Continued*)

Configuration	Symbol	J	Term value	g-value
—	6°	6	*36781.6*	1.33
	7°	1	*36844.7*	1.09
	8°	2	*37342.1*	1.15
	9°	4	*37590.7*	1.25
	10°	3	*37769.0*	1.17
—	11°	5	*38536.2*	1.30
	12°	2	*38815.9*	0.88
	13°	4	*40194.2*	1.21
	14°	2	*40516.3*	1.38
	15°	2	*40787.9*	1.20
—	16°	0	*40873.5*	
	17°	3	*40970.1*	1.12
	18°	1	*41802.7*	0.92
	19°	3	*42660.2*	1.19
	20°	1	*43187.8*	1.39
—	21°	3	*43945.7*	1.21
	22°	4	*44432.7*	1.20
	23°	2	*44444.4*	1.21
	24°	3	*44730.3*	1.19
	25°	1	*45398.4*	1.52
—	26°	0	*46007.3*	
	27°	2	*46170.4*	1.01
	28°	2	*46419.4*	0.87
	29°	0	*46433.9*	
	30°	3	*46622.5*	1.15
—	31°	3	*46793.9*	
	32°	4	*46965.1*	1.34
	33°	1	*47740.6*	1.43
	34°	4	*48351.9*	1.25
	35°	2	*48535.6*	1.02
—	36°	3	*48779.3*	1.22
	37°	3	*49286.1*	1.19
	38°	1	*49544.5*	1.24
	39°	2	*49880.8*	1.12
	40°	1	*50055.3*	0.87

(*Concluded*)

Configuration	Symbol	J	Term value		g-value
—	41°	3	*51097.5*		1.21
	42°	2	*51286.9*		1.13
	43°	2	*51545.5*		1.25
	44°	2	*51752.3*		1.34
	45°	1	*52071.6*		1.22
$5d^9\ (^2D_{2\frac{1}{2}})\ 7s$	1	3	52379.3	^3D	1.32
	2	2	52667.2	^3D	1.04
—	46°	2	*52708.3*		1.46
	47°	1	*53019.2*		1.08
	48°	2	*53955.3*		1.32
	49°	3	*54839.2*		1.21
	50°	1, 2	*55216.8*		0.96
—	51	5	55640.7		1.41
	52	4	56784.4		1.27
	53	3	59731.5		1.3
	54	3	59751.2		
	55	3	59764.3		1.27
—	56	1	59782.8		1.07
	57	3	59872.1		1.23
	58	4	59882.4		1.17
	59	2	59908.1		1.02
$5d^9\ (^2D_{1\frac{1}{2}})\ 7s$	3	1	60357.8	^3D	0.52
	4	2	60640.6	^1D	1.08
—	60	3	60790.4		1.07
	61	4	60884.0		1.29
	62	4, 5	64129.1		
	63	6	64141.3		
	64	4	64505.9		

Ra II $\qquad Z = 88$

87 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p^6\ 7s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 10.2 volts

These terms can be found in Fowler and Paschen-Götze. The absolute value of the lowest state is 56653 cm.$^{-1}$.

Configuration	Symbol	J	Term value	$\Delta\nu$
$7s$	^2S	$\frac{1}{2}$	0	
$7p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*21351.61* *26208.82*	4857.21
$8s$	^2S	$\frac{1}{2}$	43405.07	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	48743.9 49240.28	496.4

Rb I $Z = 37$

37 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,5s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 4.159 volts

This classification can be found in Fowler and Paschen-Götze. The first table gives the low terms only, the other tables contain all terms in series arrangement.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s$	^2S	$\frac{1}{2}$	33689.1	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*21110.2* *20872.6*	237.6
$4d$	^2D	$1\frac{1}{2}$	14334.3	
$6s$	^2S	$\frac{1}{2}$	13557.9	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*9974.1* *9896.6*	77.5
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	7988.9 7985.9	3.0
$7s$	^2S	$\frac{1}{2}$	7378.1	
$4f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*6897.6*	

SERIES

ms	
m	$^2S_{\frac{1}{2}}$
5	33689.1
6	13557.9
7	7378.1
8	4642.9
9	3191.2
10	2328.5
11	1773.8
12	1397.4

(*Concluded*)

mp		
m	$^2P_{\frac{1}{2}}^{\circ}$	$^2P_{1\frac{1}{2}}^{\circ}$
5	*21110.2*	*20872.6*
6	*9974.1*	*9896.6*
7	*5854.2*	*5819.2*
8	*3854.2*	*3835.5*
9	*2729.8*	*2719.6*
10	*2033.8*	*2028.2*

mp		*mp*	
m	$^2P_{\frac{1}{2},\,1\frac{1}{2}}^{\circ}$	*m*	$^2P_{\frac{1}{2},\,1\frac{1}{2}}^{\circ}$
11	*1573.3*	23	*265.2*
12	*1254.8*	24	*240.8*
13	*1024.2*	25	*219.2*
14	*849.3*	26	*201.7*
15	*718.0*	27	*186.0*
16	*614.6*	28	*170.6*
17	*531.7*	29	*157.5*
18	*464.1*	30	*146.3*
19	*409.7*	31	*136.2*
20	*363.6*	32	*127.1*
21	*325.3*	33	*119.1*
22	*292.0*	34	*111.1*

md		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
4	14334.3	Unresolved
5	7988.9	7985.9
6	5002.4	5000.2
7	3409.6	3407.7
8	2468.2	2467.0
9	1868.8	1867.6
10	1464.6	1463.5
11	1182.7	1176.7

mf	
m	$^2F_{2\frac{1}{2},\,3\frac{1}{2}}^{\circ}$
4	*6897.6*
5	*4418.2*
6	*3068.0*
7	*2252.4*

Rb II $\quad Z = 37$

36 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\ {}^1S_0$

Ionization potential about 27.3 volts

This classification has been given by Miller and Laporte. The p^5d and p^5s levels overlap and cannot be distinguished with certainty. The probable identification of the p^5s levels given by Miller and Laporte is indicated in the last column. The absolute value of the lowest state is given as 221852 cm.$^{-1}$ with respect to the $4p^5\ {}^2P_{1\frac{1}{2}}$ of Rb III.

Reference

G. R. Miller and O. Laporte, unpublished material.

Configuration	Symbol	J	Term value	
$4p^6$	^1S	0	0	
$4p^5\,4d$	1°	1	*126453.53*	
and	2°	2	*128693.70*	
$4p^5\,5s$	9°	2	*133347.29*	$4p^5\,5s\ {}^3P$
	10°	1	*134875.14*	$4p^5\,5s\ {}^3P$
	3°	2	*135554.21*	
	4°	0	*138799.56*	
	5°	1	*140615.18*	
	11°	0	*141879.24*	$4p^5\,5s\ {}^3P$
	6°	1, 2	*143027.39*	
	12°	1	*143467.00*	$4p^5\,5s\ {}^1P$
	7°	2	*143960.94*	
	8°	1, 2	*145630.06*	
$4p^5\,5p$	1	1	154279.25	
	2	2	156742.20	
	3	3	156900.72	
	4	1	158156.66	
	5	2	158717.04	
	6	0	161204.13	
	7	1	163929.47	
	8	2	164972.81	
	9	1	165094.55	
	10	0	167367.30	

(*Concluded*)

Configuration	Symbol	J	Term value	
$4p^5\,5d$ and $4p^5\,6s$	13°	2	*179740.11*	$4p^5\,6s\;^3P$
	14°	1	*180173.33*	$4p^5\,6s\;^3P$
	15°	1	*184205.27*	
	16°	2	*184841.65*	
	17°	3	*185131.62*	
	18°	2	*185622.53*	
	19°	3	*186010.87*	
	20°	1	*187340.37*	
	21°	1	*188622.28*	$4p^5\,6s\;^1P$
	22°	1	*189006.27*	
	23°	1, 2	*192380.15*	

75 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^5\ 6s^2\ {}^6S_{2\frac{1}{2}}$

Several strong lines of the arc spectrum of rhenium have been classified by Meggers. Many of the lines show hyperfine structure.

Reference

W. F. Meggers, *Phys. Rev.* **37**, 219 (1931).

Configuration	Symbol	J	Term value
$5d^5\,6s^2$	${}^6S$	$2\frac{1}{2}$	0
—	${}^6P^\circ$	$2\frac{1}{2}$	*18946.3*
		$1\frac{1}{2}$	*18966.5*
		$3\frac{1}{2}$	*20447.6*
—	${}^6P^\circ$	$2\frac{1}{2}$	*28854.3*
		$3\frac{1}{2}$	*28889.3*
		$1\frac{1}{2}$	*28961.3*
—	${}^6S$	$2\frac{1}{2}$	44703.3

Rh I $\qquad Z = 45$

45 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,4d^{10}\,4s^2\,4p^6\,4d^8\,5s\ {}^4F_{4\frac{1}{2}}$

Ionization potential = 7.7 volts with respect to $4d^8\ {}^3F$

In this table the work of Sommer is followed. The g-values obtained by Sommer for a few levels have been indicated. The division into multiplets and the assignment of electron configurations is uncertain.

References

L. A. Sommer, *Zeits. f. Physik* **45**, 147 (1927).
W. F. Meggers and C. C. Kiess, *Journ. Opt. Soc. Am.* **12**, 417 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$	g-value
$4d^8\,({}^3F)\,5s$	${}^4F$	$4\frac{1}{2}$	0		
				−1530.0	
		$3\frac{1}{2}$	1530.0		
				−1068.1	
		$2\frac{1}{2}$	2598.1		1.06
				−874.6	
		$1\frac{1}{2}$	3472.7		0.47
$4d^9$	${}^2D$	$2\frac{1}{2}$	3309.9		
				−2348.1	
		$1\frac{1}{2}$	5658.0		0.82
$4d^8\,({}^3F)\,5s$	${}^2F$	$3\frac{1}{2}$	5690.0		1.19
				−2100.3	
		$2\frac{1}{2}$	7791.2		
$4d^8\,({}^3P)\,5s$	${}^4P$	$2\frac{1}{2}$	9221.2		1.48
				−1092.3	
		$1\frac{1}{2}$	10313.5		1.58
				−692.7	
		$\frac{1}{2}$	11006.2		2.56
$4d^8\,({}^3P)\,5s$	${}^2P$	$1\frac{1}{2}$	11968.4		
				−2006.6	
		$\frac{1}{2}$	13975.0		0.71
$4d^7\,5s^2$	${}^4F$	$4\frac{1}{2}$	12723.3		
				−2064.8	
		$3\frac{1}{2}$	14788.1		
				−1330.8	
		$2\frac{1}{2}$	16118.9		
				−825.0	
		$1\frac{1}{2}$	16943.9		
$4d^8\,({}^1D)\,5s$	${}^2D$	$2\frac{1}{2}$	13520.9		
				−861.5	
		$1\frac{1}{2}$	14382.4		

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	g-value
$4d^8\ (^1G)\ 5s$	^2G	$4\frac{1}{2}$	16018.2	-102.7	
		$3\frac{1}{2}$	16120.9		
$4d^8\ (^3F)\ 5p$	$^4D°$	$3\frac{1}{2}$	*27075.6*	-1784.4	
		$2\frac{1}{2}$	*28860.0*	-1537.5	
		$1\frac{1}{2}$	*30397.5*	-749.5	
		$\frac{1}{2}$	*31147.0*		0.0
$4d^8\ (^3F)\ 5p$	$^4G°$	$4\frac{1}{2}$	*28543.0*		
		$5\frac{1}{2}$	*29104.6*		
		$3\frac{1}{2}$	*31102.0*		0.75
		$2\frac{1}{2}$	*32243.5*		0.96
$4d^8\ (^3F)\ 5p$	$^4F°$	$4\frac{1}{2}$	*29431.1*	-435.4	
		$3\frac{1}{2}$	*29866.5*	-1608.3	
		$2\frac{1}{2}$	*31474.8*	-802.8	0.82
		$1\frac{1}{2}$	*32277.6*		0.48
$4d^8\ (^3F)\ 5p$	$^2G°$	$4\frac{1}{2}$	*31613.9*	-1430.2	
		$3\frac{1}{2}$	*33044.1*		
$4d^8\ (^3F)\ 5p$	$^2F°$	$3\frac{1}{2}$	*32004.1*	-1942.4	
		$2\frac{1}{2}$	*33946.5*		
$4d^8\ (^3F)\ 5p$	$^2D°$	$2\frac{1}{2}$	*32046.5*	-1820.7	(1.09)?
		$1\frac{1}{2}$	*33867.2*		
$4d^8\ (^3P)\ 5p$	$^4P°$	$2\frac{1}{2}$	*35333.9*	-70.4	
		$1\frac{1}{2}$	*35404.3*	-265.3	
		$\frac{1}{2}$	*35669.6*		2.06
—	1°	$3\frac{1}{2}$	*36132.7*		
$4d^8\ (^3P)\ 5p$	$^4D°$	$3\frac{1}{2}$	*36787.4*	-197.8	1.24
		$2\frac{1}{2}$	*36985.2*	-1053.1	(1.13)?
		$1\frac{1}{2}$	*38038.3*	-436.1	0.0
		$\frac{1}{2}$	*38474.4*		
—	2°	$\frac{1}{2}$	*37368.6*	$^2P°$	
	3°	—	*38012.9*		
	4°	$1\frac{1}{2}$	*38211.1*	$^2P°$	1.26

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	g-value
—	5°	$1\frac{1}{2}$	*38668.9*	$^2P^\circ$	
	6°	$2\frac{1}{2}$	*38718.1*	$^2D^\circ$	
	7°	$\frac{1}{2}$	*38806.6*	$^2S^\circ$	
	8°	$2\frac{1}{2}$	*39126.7*	$^2D^\circ$	
	9°	$1\frac{1}{2}$	*39231.4*	$^2P^\circ$	1.28
	10°	—	*39494.2*		
	11°	—	*39525.4*		
	12°	$2\frac{1}{2}$	*39788.2*	$^2D^\circ$	
	13°	$2\frac{1}{2}$	*39981.5*	$^2D^\circ$	
	14°	—	*40134.6*		
	15°	$3\frac{1}{2}$	*40285.2*	$^2F^\circ$	
	16°	$2\frac{1}{2}$	*40577.3*	$^2F^\circ$	
	17°	$1\frac{1}{2}$	*40603.8*	$^4S^\circ$	
	18°	$\frac{1}{2}$	*40604.9*	$^2P^\circ$	
	19°	$1\frac{1}{2}$	*40900.3*	$^2D^\circ$	
	20°	—	*41444.5*		
$4d^8\ (^3F)\ 6s$	^4F	$4\frac{1}{2}$	41881.1		
		$3\frac{1}{2}$	44444.8		
		$1\frac{1}{2}$	45471.4		
		$2\frac{1}{2}$	45811.8		
$4d^8\ (^3F)\ 6s$	^2F	$3\frac{1}{2}$	42292.8	−2182.1	
		$2\frac{1}{2}$	44474.9		
—	21°	$1\frac{1}{2}$	*42431.8*	$^2P^\circ$	1.39
	22°	$3\frac{1}{2}$	*42495.8*	$^4F^\circ$	
	23°	—	*43042.5*		
	24°	$3\frac{1}{2}$	*43047.8*	$^2F^\circ$	
	25°	$2\frac{1}{2}$	*43421.6*	$^4F^\circ$	
	26°	$\frac{1}{2}$	*43729.2*	$^2P^\circ$	
	27°	$2\frac{1}{2}$	*43777.2*	$^2F^\circ$	
	28°	$3\frac{1}{2}$	*44588.3*	$^4D^\circ$	
	29°	—	*44621.0*		
	30°	$2\frac{1}{2}$	*44786.8*	$^4F^\circ$	
	31°	$2\frac{1}{2}$	*45673.5*	$^4D^\circ$	
	32	—	46160.5		
	33°	$1\frac{1}{2}$	*46280.0*	$^4D^\circ$	
	34°	$\frac{1}{2}$	*46752.8*	$^4D^\circ$	

(*Continued*)

Configuration	Symbol	J	Term value	
—	35	3½	47713.7	^4D
	36	6½	47775.7	^4H
	37	5½	47793.9	^4H
	38	2½	47832.4	^4D
	39	4½	47857.7	^4F
	40	5½	47862.0	^4G
	41	3½	47897.0	^4F
	42	4½	47928.4	^4G
—	43°	—	*47954.1*	
	44°	—	*48797.6*	
—	45	2½	50043.1	^4P
	46	2½	50112.1	^4D
	47	4½	50191.1	^4H
	48	5½	50199.3	^2H
	49	2½	50208.0	^2D
	50	3½	50233.3	^2F
	51	4½	50277.9	^2G
	52	3½	50285.0	^4G
	53	1½	50290.2	D
	54	2½	50408.5	^4F
	55	1½	50452.3	^4D
—	56°	1½	*50721.1*	$^4F°$
—	57	2½	51324.6	F
	58	2½	51356.2	^4G
	59	1½	51419.4	^4F
	60	2½	51477.4	D, F
—	61°	—	*51608.5*	
—	62	1½	51626.0	^2D
	63	2½	51636.5	^2F
—	64°	—	*52065.5*	
—	65	1½	52413.2	P
	66	½	52473.4	P
	67	1½, 2½	53223.8	D, F
—	68°	—	*53599.8*	

(*Concluded*)

Configuration	Symbol	J	Term value	
—	69	$2\frac{1}{2}$	55898.5	P, D
	70	$1\frac{1}{2}$, $2\frac{1}{2}$	56087.5	P, D
	71	$1\frac{1}{2}$	57610.6	P
	72	$2\frac{1}{2}$	58111.2	D
	73	$4\frac{1}{2}$	58315.8	^4G
	74	$2\frac{1}{2}$	60744.5	
	75	$2\frac{1}{2}$	61618.2	
	76	—	63544.6	
	77	$2\frac{1}{2}$, $3\frac{1}{2}$	63711.5	G
	78	$3\frac{1}{2}$	63891.1	G
	79	$1\frac{1}{2}$, $2\frac{1}{2}$	64127.3	F, D
	80	$1\frac{1}{2}$, $2\frac{1}{2}$	64560.1	F, G
	81	$1\frac{1}{2}$, $2\frac{1}{2}$	64971.0	$P_{1\frac{1}{2}}$, $D_{2\frac{1}{2}}$
	82	$\frac{1}{2}$, $1\frac{1}{2}$	65236.5	
	83	$1\frac{1}{2}$	66437.6	P
	84	$1\frac{1}{2}$	66578.5	D
	85	$1\frac{1}{2}$, $2\frac{1}{2}$	66900.4	

44 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^8\ {}^3F$

These terms are from the unpublished material of Livingood and Shenstone. While multiplet notation is used, it is to be noted that multiplets from $4d^7\,5p$ overlap considerably. The lowest state, $4d^8\ {}^3F$, has not yet been found.

Reference

J. J. Livingood and A. G. Shenstone, unpublished material.

Cofiguration	Symbol	J	Term value	$\Delta\nu$
$4d^7\ ({}^4F)\ 5s$	${}^5F$	5	0.0	
		4	1655.8	−1655.8
		3	2907.6	−1251.8
		2	3761.7	−854.1
		1	4294.9	−533.2
$4d^7\ ({}^4F)\ 5s$	${}^3F$	4	8492.1	
		3	10554.6	−2062.5
		2	11949.6	−1395.0
$4d^7\ ({}^4P)\ 5s$	${}^5P$	3	10916.6	
		2	11246.6	−330.0
		1	12188.0	−941.4
$4d^7\ ({}^4F)\ 5p$	${}^5F^\circ$	5	*40136.2*	
		4	*39662.3*	473.9
		3	*41473.8*	−1811.5
		2	*42813.5*	−1339.7
		1	*43688.3*	−874.8
$4d^7\ ({}^4F)\ 5p$	${}^5D^\circ$	4	*42276.8*	
		3	*43563.6*	−1286.8
		2	*44471.0*	−907.4
		1	*44996.1*	−525.1
		0	*45127.7*	−131.6

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^7\ (^4F)\ 5p$	$^5G^\circ$	6	*42817.1*	−27.2
		5	*42844.3*	−1443.8
		4	*44288.1*	−766.7
		3	*45054.8*	−348.7
		2	*45403.5*	
$4d^7\ (^4F)\ 5p$	$^3G^\circ$	5	*46309.6*	−765.1
		4	*47074.7*	−1361.4
		3	*48436.1*	
$4d^7\ (^4F)\ 5p$	$^3F^\circ$	4	*45441.2*	−1128.7
		3	*46569.9*	−1515.3
		2	*48085.2*	
$4d^7\ (^4F)\ 5p$	$^3D^\circ$	3	*47934.7*	−1258.7
		2	*49193.4*	−691.0
		1	*49884.4*	
$4d^7\ (^4P)\ 5p$	$^5S^\circ$	2	*46376.6*	
$4d^7\ (^4P)\ 5p$	$^5P^\circ$	1	*52137.8*	17.5
		2	*52155.3*	115.0
		3	*52270.3*	
$4d^7\ (^4P)\ 5p$	$^5D^\circ$	0	*53313.7*	343.2
		1	*53656.9*	816.9
		2	*54473.8*	348.7
		3	*54822.5*	−701.9
		4	*54120.6*	

Rn I $\qquad\qquad$ $Z = 86$

86 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p^6\ {}^1S_0$

Ionization potential = 10.69 volts

This classification is taken from the work of Rasmussen.

Reference

E. Rasmussen, *Zeits. f. Physik* **62**, 494 (1930).

Configuration	Symbol	J	Term value	
$6p^6$	${}^1S$	0	86691.2	
$6p^5\ ({}^2P_{1\frac{1}{2}})\ 7s$	1°	2	*32072.5*	${}^3P_2^\circ$
	2°	1	*30703.5*	${}^3P_1^\circ$
$6p^5\ ({}^2P_{1\frac{1}{2}})\ 7p$	1	1, 2	20447.8	
	2	2, 1	19985.3	
	3	3	18653.0	
	4	1, 2	18360.5	
	5	2, 1	17902.9	
	6	0	16948.5	
$6p^5\ ({}^2P_{\frac{1}{2}})\ 7s$	3°	0	*18783.3*	${}^3P_0^\circ$
	4°	1	*17799.1*	${}^1P_1^\circ$

SERIES

	$6p^5\ ({}^2P_{1\frac{1}{2}})\ ms$		$6p^5\ ({}^2P_{\frac{1}{2}})\ ms$	
m	$1_2^\circ\ (s_5)$	$2_1^\circ\ (s_4)$	$3_0^\circ\ (s_3)$	$4_1^\circ\ (s_2)$
7	*32072.5*	*30703.5*	*18783.3*	*17799.1*
8	—			
9	—			
10	*4481.7*			
11	*3097.0*			
12	*2269.5*			

(*Concluded*)

$6p^5\ (^2P_{1\frac{1}{2}})\ mp$						
m	$1_{1,2}\ (p_{10})$	$2_{2,1}\ (p_9)$	$3_3\ (p_8)$	$4_{1,2}\ (p_7)$	$5_{2,1}\ (p_6)$	$6_0\ (p_5)$
7	20447.8	19985.3	18653.0	18360.5	17902.9	16948.5
8	9653.5	9530.7	9088.1	9014.8	8865.0	8529.4
9	5692.4	5641.1	5438.3	5409.0	5341.0	5184.0
10	3763.4	3738.3	3627.7	3611.7	3573.8	3498.0
11			2593.5	2584.0	2561.0	2507.9
12			1946.5		1925.6	

$6p^5\ (^2P_{1\frac{1}{2}})\ md$							
m	$1_0°\ (d_6)$	$2_1°\ (d_2)$	$3_4°\ (d_4')$	$4_1°\ (d_5)$	$5_3°\ (d_4)$	$6_1°\ (d_1'')$	$7_3°\ (d_1')$
6	—	—	—	—	—	—	—
7	—	—	—	—	—	—	—
8	—	—	—	—	*8461.7*	—	—
9	*5458.4*	*5362.9*	—	*5202.1*	*5178.3*	*5073.4*	—
10	*3650.0*	*3596.2*	*3520.3*	*3505.9*	*3493.4*	*3438.3*	*3395.7*
11	*2617.6*	*2581.1*	*2530.4*	*2522.7*	*2515.3*	*2482.7*	*2456.0*
12			*1906.6*	*1901.5*	*1897.1*	*1876.2*	*1858.9*
13			*1488.0*		*1480.6*		

$6p^5\ (^2P_{1\frac{1}{2}})\ mf$			
m	$1_1\ (X)$	$2_{2,1}\ (Y)$	$3\ (Z)$
8	7053.7	7047.1	6946.6
9	4499.3	4495.2	4445.3
10	3114.6	3111.4	3083.1
11	2281.8	2280.9	

Ru I $\qquad Z = 44$

44 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^7\ 5s\ {}^5F_5$

The terms of this spectrum have been taken from a paper by Sommer, who also investigated the Zeeman effect. The multiplet assignments and electron configurations could be given for only a few levels, the two lowest multiplets being the only ones which are certain.

References

L. A. Sommer, *Zeits. f. Physik* **37**, 1 (1926).
W. F. Meggers and O. Laporte, *Phys. Rev.* **28**, 642 (1926).
W. F. Meggers and C. C. Kiess, *Journ. Opt. Soc. Am.* **12**, 417 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$	
$4d^7\ ({}^4F)\ 5s$	${}^5F$	5	0		
		4	1190.6	1190.6	
		3	2091.5	900.9	
		2	2713.2	621.7	
		1	3105.5	392.3	
$4d^7\ ({}^4F)\ 5s$	${}^3F$	4	6544.9		
		3	8084.0	1539.1	
		2	9057.4	973.1	
$4d^6\ 5s^2$	${}^5D$	4	7483.0		
		3	8575.2	1092.2	
		2	9183.2	608.0	
		1	9619.8	436.6	
		0	—	—	
—	1	2	8043.6		${}^5P_2$
	2	3	8770.7		${}^5P_3$
	3	1	9072.6		${}^5P_1$
—	${}^3F$	4	9120.3		
		3	10654.0	1533.7	
		2	11446.8	792.8	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$	
—	4	2	10623.0		$^3P_2$?
	5	0	11752.1		$^3P_0$?
	6	1	11785.5		
	7	4	12816.1		
	8	2	13645.2		$^3D_2$?
	9	1	13981.1		$^3P_1$?
	10	2	15053.6		
—	11°	4	*25464.5*		
	12°	3	*26035.6*		
$4d^7\ (^4F)\ 5p$	$^5D^\circ$	4	*26312.9*	1193.8	
		3	*27506.7*	959.1	
		2	*28465.8*	652.6	
		1	*29118.4*	—	
		0	—		
$4d^7\ (^4F)\ 5p$	$^5F^\circ$	5	*26816.3*	1198.5	
		4	*28014.8*	875.2	
		3	*28890.5*	536.8	
		2	*29427.3*	266.2	
		1	*29693.5*		
—	13°	5	*28495.2*		$^{5,3}G$?
$4d^7\ (^4F)\ 5p$	$^5G^\circ$	6	*28571.8*		
		4	*29890.9*		
		5	*30279.6*		
		3	*30537.0*		
		2	*30958.8*		
—	14°	2	*30018.2*		
	15°	4	*30250.3*		
	16°	4	*30348.3*		
	17°	3	*31044.3*		
	18°	2	*31186.0*	$^5S_2$	
	19°	4	*31345.6*	$^3G_4$?	
	20°	3	*31384.6*		
	21°	3	*31853.0*	^3G	
	22°	2	*32207.8*		
	23°	2	*32343.4*	$^3F_3$?	
	24°	3	*32392.0*	$^3F_3$?	
	25°	2	*33172.1*	$^3D_2$?	

(*Continued*)

Configuration	Symbol	J	Term value	
—	26°	3	*33430.7*	$^3D_3$?
	27°	4	*33446.9*	
	28°	1	*33580.3*	$^3D_1$
	29°	2	*33728.8*	$^5P_2$?
	30°	3	*34072.6*	
	31°	1	*34091.2*	
	32°	2	*34881.8*	
	33°	4	*35471.1*	
	34°	3	*35806.5*	
	35°	3	*36760.3*	
	36°	1, 2	*36965.3*	
	37°	2	*37118.9*	
	38°	1	*37619.5*	
	39°	2	*37667.9*	
	40°	1	*38200.3*	
	41°	1	*38587.2*	
	42°	3	*38706.5*	
	43°	2	*39008.8*	
	44°	3, 4	*39037.5*	
	45°	3	*39433.9*	
	46°	2	*39742.2*	
	47°	1	*39916.7*	
	48°	3 ?	*40025.8*	
	49°	3	*40235.7*	
	50°	4	*40276.9*	
	51°	4	*40439.6*	
	52°	3	*40768.6*	
	53°	3	*40949.1*	
	54°	1	*41183.4*	
	55°	3	*41260.5*	
	56°	3	*41483.1*	
	57°	2	*41756.6*	
	58°	3	*41881.3*	
	59°	2	*42007.6*	
—	60	4	42895.7	
	61	4	43018.9	
	62	4	43115.7	$^3F_4$?
—	63°	2	*43509.5*	
	64°	3	*43976.1*	
—	65	3	44176.4	$^3F_3$?

(*Concluded*)

Configuration	Symbol	J	Term value	
—	66°	2	*44235.0*	
	67°	4	*44243.8*	
—	68	2	44970.2	$^3F_2$?
—	69°	3	*45071.8*	
	70°	2	*45790.7*	
	71°	4	*46400.9*	
—	72	5	46907.5	
—	73°	2, 3	*46946.5*	
—	74	5	47085.9	
	75	3, 4	47189.5	
	76	4	47488.1	
	77	3	47601.7	
	78	2	49514.6	
	79	2, 3, 4	49555.1	
	80	4	49556.3	
	81	2	49759.0	
	82	2, 3	49883.0	
	83	2	50522.2	
	84	2	51619.3	

Ru II $\qquad Z = 44$

43 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^7\ {}^4F_{4\frac{1}{2}}$

These terms are from the unpublished material of Meggers and Shenstone. The quartets from $4d^6\,(^5D)\,5p$ overlap considerably. The g-values are regular for all the low even terms and, with a few exceptions, for the odd terms.

References

W. F. Meggers and A. G. Shenstone, *Phys. Rev.* **35**, 868 (1930).
W. F. Meggers and A. G. Shenstone, unpublished material.

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^7$	^4F	$4\frac{1}{2}$	0.0	
				−1523.0
		$3\frac{1}{2}$	1523.0	
				−971.0
		$2\frac{1}{2}$	2494.0	
				−610.2
		$1\frac{1}{2}$	3104.2	
$4d^7$	^4P	$2\frac{1}{2}$	8256.8	
				−220.6
		$1\frac{1}{2}$	8477.4	
				−896.2
		$\frac{1}{2}$	9373.6	
$4d^6\,(^5D)\,5s$	^6D	$4\frac{1}{2}$	9151.5	
				−999.1
		$3\frac{1}{2}$	10150.6	
				−701.2
		$2\frac{1}{2}$	10851.8	
				−451.8
		$1\frac{1}{2}$	11303.6	
				−300.5
		$\frac{1}{2}$	11604.1	
$4d^6\,(^5D)\,5s$	^4D	$3\frac{1}{2}$	19378.7	
				−1136.2
		$2\frac{1}{2}$	20514.9	
				−731.3
		$1\frac{1}{2}$	21246.2	
				−399.3
		$\frac{1}{2}$	21645.5	
$4d^7$	^2F	$2\frac{1}{2}$	21557.8	
				731.2
		$3\frac{1}{2}$	22289.0	
$4d^6\,(^5D)\,5p$	$^6D^\circ$	$4\frac{1}{2}$	*46470.9*	
				−240.5
		$3\frac{1}{2}$	*46711.4*	
				−573.5
		$2\frac{1}{2}$	*47284.9*	
				−423.5
		$1\frac{1}{2}$	*47708.4*	
				−275.3
		$\frac{1}{2}$	*47983.7*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^6\ (^5D)\ 5p$	$^6F^\circ$	$5\frac{1}{2}$	*50758.2*	
		$4\frac{1}{2}$	*50845.3*	−87.1
		$3\frac{1}{2}$	*50862.5*	−17.2
		$2\frac{1}{2}$	*51179.4*	−316.9
		$1\frac{1}{2}$	*51316.6*	−137.2
		$\frac{1}{2}$	*51379.8*	−63.2
$4d^6\ (^5D)\ 5p$	$^6P^\circ$	$3\frac{1}{2}$	*51548.8*	
		$2\frac{1}{2}$	*52820.3*	−1271.5
		$1\frac{1}{2}$	*53685.1*	−864.8
$4d^6\ (^5D)\ 5p$	$^4F^\circ$	$4\frac{1}{2}$	*52964.3*	
		$3\frac{1}{2}$	*54225.4*	−1261.1
		$2\frac{1}{2}$	*54794.2*	−568.8
		$1\frac{1}{2}$	*55223.9*	−429.7
$4d^6\ (^5D)\ 5p$	$^4D^\circ$	$3\frac{1}{2}$	*53316.9*	
		$2\frac{1}{2}$	*54065.1*	−748.2
		$1\frac{1}{2}$	*54663.2*	−598.1
		$\frac{1}{2}$	*54981.2*	−318.0
$4d^6\ (^5D)\ 5p$	$^4P^\circ$	$2\frac{1}{2}$	*55694.9*	
		$1\frac{1}{2}$	*56664.6*	−969.7
		$\frac{1}{2}$	*57263.3*	−598.7

S I $Z = 16$

16 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4\ {}^3P_2$

First ionization potential = 10.3 volts

The classification of the first spectrum of sulphur has been given according to Paschen-Götze, Hopfield, and Bungartz. It is for the most part incomplete and in many cases the identifications are questionable.

References

J. J. Hopfield, *Nature* **112**, 437 (1923).
E. Bungartz, *Ann. d. Physik* **76**, 709 (1925).
J. J. Hopfield and G. H. Dieke, *Phys. Rev.* **27**, 638 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p^4$	^3P	2 1 0	83554 83156 82982	−398 −174
$3s^2\ 3p^3\ (^4S)\ 4s$	$^5S°$	2	*30935.8*	
$3s^2\ 3p^3\ (^4S)\ 4s$	$^3S°$	1	*28228*	
$3p^3\ (^4S)\ 4p$	^5P	1 2 3	20113.9 20102.7 20084.8	11.2 17.9
$3p^3\ (^4S)\ 3d$	$^3D°$	1, 2, 3	*15666*	
$3p^3\ (^4S)\ 4s$	$^3S°$	1	*13389*	
$3p^3\ (^4S)\ 4d$	$^3D°$	1, 2, 3	*12207*	
$3s\ 3p^5$	^3P	2 1 0	11535 11174 10985	−361 −189

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2 3p^3 (^4S)\ 5p$	^3P	1 2 3	9649.1 9645.5 9639.5	3.6 6.0
$3p^3 (^4S)\ 4d$	^5D	0, 1, 2, 3, 4	8586	
$3p^3 (^4S)\ 5s$	$^3S^\circ$	1	*7606*	
$3p^3 (^4S)\ 6s$	$^5S^\circ$	2	*7096.5*	
$3p^3 (^4S)\ 5d$	$^3D^\circ$	1, 2, 3	*6833*	
$3p^3 (^4S)\ 5d$	$^5D^\circ$	0, 1, 2, 3, 4	*5290*	
$3p^3 (^4S)\ 7s$	$^5S^\circ$	2	*4502.2*	
$3p^3 (^4S)\ 6d$	$^5D^\circ$	0, 1, 2, 3, 4	*3568*	
$3p^3 (^4S)\ 8s$	$^5S^\circ$	2	*3111*	
$3p^3 (^4S)\ 7d$	$^5D^\circ$	0, 1, 2, 3, 4	*2565.5*	
$3p^3 (^4S)\ 9s$	$^5S^\circ$	2	*2279*	
$3p^3 (^4S)\ 8d$	$^5D^\circ$	0, 1, 2, 3, 4	*1931.7*	
$3p^3 (^4S)\ 10s$	$^5S^\circ$	2	*1741*	
$3p^3 (^4S)\ 9d$	$^5D^\circ$	0, 1, 2, 3, 4	*1506.6*	
$3p^3 (^4S)\ 10d$	$^5D^\circ$	0, 1, 2, 3, 4	*1207.5*	

S II $Z = 16$

15 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^3\ {}^4S_{1\frac{1}{2}}^{\circ}$

First ionization potential = 23.3 volts

The classification of this spectrum is given largely by Ingram with additions made by L. and E. Bloch. The absolute value of the lowest state has been obtained from only two members in the series $ms\ {}^4P$ and $ms\ {}^2P$ and found to be 188824 cm.$^{-1}$ with respect to $3p^2\ {}^3P$ of S III.

References

S. B. Ingram, *Phys. Rev.* **32,** 173 (1928).
J. Gilles, *Comptes Rendus,* **186,** 1109 (1928).
D. K. Bhattacharya, *Proc. Roy. Soc.* **A122,** 416 (1929).
L. and E. Bloch, *Comptes Rendus,* **188,** 160 (1929); *Ann. de Physique,* **12,** 5 (1929).
I. S. Bowen, *Nature* **123,** 450 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^3$	$^4S^{\circ}$	$1\frac{1}{2}$	*0.0*	
$3s^2\,3p^3$	$^2D^{\circ}$	$1\frac{1}{2}$	*14851.9*	31.5
		$2\frac{1}{2}$	*14883.4*	
$3s^2\,3p^3$	$^2P^{\circ}$	$\frac{1}{2}$	*24524.2*	48.6
		$1\frac{1}{2}$	*24572.8*	
$3s\ 3p^4$	^4P	$2\frac{1}{2}$	79394.8	−363.1
		$1\frac{1}{2}$	79757.9	−210.1
		$\frac{1}{2}$	79968.0	
$3s\ 3p^4$	^2P	$\frac{1}{2}$	106044.02	445.08
		$1\frac{1}{2}$	105598.94	
$3s^2\,3p^2\,(^3P)\,4s$	^4P	$\frac{1}{2}$	109560.50	290.83
		$1\frac{1}{2}$	109831.33	437.00
		$2\frac{1}{2}$	110268.33	
$(^3P)\,3d$	^4F	$1\frac{1}{2}$	110176.83	136.30
		$2\frac{1}{2}$	110313.13	195.35
		$3\frac{1}{2}$	110508.48	257.83
		$4\frac{1}{2}$	110766.31	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^2\,(^3P)\,4s$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	112937.30 113144.22	206.92
$(^3P)\,3d$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	114162.20 114200.45 114230.86 114279.30	38.25 30.41 48.44
$3s^2\,3p^2\,(^3P)\,3d$	^2F	$2\frac{1}{2}$ $3\frac{1}{2}$	114804.19 114969.14	64.95
$(^3P)\,3d$	^2P	$1\frac{1}{2}$	118146.93	
$(^3P)\,3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	119242.13 119295.03	52.90
$3s^2\,3p^2\,(^1D)\,4s$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	121529.43 121529.99	1.56
$(^3P)\,4p$	$^2S°$	$\frac{1}{2}$	*125485.1*	
$3s^2\,3p^2\,(^3P)\,4p$	$^4D°$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	*127824.99* *127976.22* *128233.02* *128599.05*	151.23 256.80 366.03
$3s^2\,3p^2\,(^3P)\,4p$	$^4P°$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*129787.69* *129858.07* *130134.02*	70.38 275.95
$(^3P)\,4p$	$^2D°$	$1\frac{1}{2}$ $2\frac{1}{2}$	*130641.04* *131187.13*	546.09
$(^3P)\,4p$	$^4S°$	$1\frac{1}{2}$	*131028.76*	
—	1	$2\frac{1}{2}$ or $3\frac{1}{2}$	131118.27	
$(^3P)\,4p$	$^2P°$	$\frac{1}{2}$ $1\frac{1}{2}$	*133268.60* *133399.87*	131.27
—	2°	$\frac{1}{2}$ or $1\frac{1}{2}$	*133359.4*	
—	3	$2\frac{1}{2}$ or $3\frac{1}{2}$	139486.31	
—	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	139845.6 140015.7	170.1

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^2\,(^1D)\,4p$	$^2F^\circ$	$2\frac{1}{2}$	*140229.97*	89.33
		$3\frac{1}{2}$	*140319.30*	
$(^1D)\,4p$	$^2D^\circ$	$2\frac{1}{2}$	*140708.85*	−41.21
		$1\frac{1}{2}$	*140750.06*	
$(^1D)\,4p$	$^2P^\circ$	$\frac{1}{2}$	*143488.87*	134.64
		$1\frac{1}{2}$	*143623.51*	
$(^3P)\,5s$	^4P	$\frac{1}{2}$	150258.48	272.73
		$1\frac{1}{2}$	150531.21	465.13
		$2\frac{1}{2}$	150996.34	
$(^3P)\,5s$	^2P	$\frac{1}{2}$	151384.09	526.79
		$1\frac{1}{2}$	151910.88	
$(^3P)\,4d$	^4F	$1\frac{1}{2}$	151959.70	134.90
		$2\frac{1}{2}$	152099.60	210.30
		$3\frac{1}{2}$	152304.90	310.62
		$4\frac{1}{2}$	152615.52	
$(^3P)\,4d$	^4D	$\frac{1}{2}$	153153.83	48.01
		$1\frac{1}{2}$	153201.84	80.27
		$2\frac{1}{2}$	153282.11	131.59
		$3\frac{1}{2}$	153413.70	
$(^3P)\,4d$	^2P	$1\frac{1}{2}$	155271.87	−346.00
		$\frac{1}{2}$	155617.87	
$(^3P)\,4d$	^4P	$2\frac{1}{2}$	155818.70	−210.66
		$1\frac{1}{2}$	156029.36	−118.05
		$\frac{1}{2}$	156148.41	
$(^3P)\,4d$	^2F	$2\frac{1}{2}$	156121.78	482.15
		$3\frac{1}{2}$	156603.93	
$(^3P)\,4d$	^2D	$1\frac{1}{2}$	158666.12	161.65
		$2\frac{1}{2}$	158827.77	
$(^1D)\,4d$	^2F	$2\frac{1}{2}$	164232.11	3.12
		$3\frac{1}{2}$	164235.23	
$(^1D)\,4d$	^2G	$4\frac{1}{2}$	164335.77 ?	1.90
		$3\frac{1}{2}$	164337.67	

S III $Z = 16$

14 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^2\;{}^3P_0$

Ionization potential = 34.9 ± 0.4 volts

The spectrum of twice ionized sulphur has been given by Gilles and by Ingram. The terms given here have been taken from Ingram's work. The absolute value of the lowest state is 282752 cm.$^{-1}$ with respect to $3p\;{}^2P_{\frac{1}{2}}$ of S IV.

References

J. Gilles, *Comptes Rendus* **188,** 63 (1929); **188,** 320 (1929).
S. B. Ingram, *Phys. Rev.* **33,** 907 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p^2$	^3P	0	0	
				300
		1	300	
				535
		2	835	
$3s\;3p^3$	$^3D^\circ$	1	*84023*	
				28
		2	*84051*	
				51
		3	*84102*	
$3s\;3p^3$	$^3P^\circ$	2	*98749*	
				−19
		1, 0	*98768*	
—	1°	1	*136847*	
$3s\;3p^3$	$^3S^\circ$	1	*138066*	
$3s^2\,3p\;3d$	$^3P^\circ$	0	*143101.89*	
				20.20
		1	*143122.09*	
				7.82
		2	*143129.91*	
$3p\;4s$	$^3P^\circ$	0	*146702.28*	
				40.24
		1	*146742.52*	
				409.48
		2	*147152.00*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p\,\,3d$	$^3D^\circ$	1	*147556.40*	
				140.69
		2	*147697.09*	
				53.39
		3	*147750.48*	
$3p\,\,4p$	^3D	1	169775.95	
				297.30
		2	170073.25	
				581.71
		3	170654.96	
$3p\,\,4p$	^3P	0	172637.32	
				154.50
		1	172791.82	
				405.88
		2	173197.70	
$3p\,\,4p$	^3S	1	174042.24	
$3p\,\,4d$	$^3F^\circ$	2	*204584.89*	
				491.86
		3	*205076.75*	
				489.92
		4	*205566.67*	
$3p\,\,4d$	$^3D^\circ$	1	*206544.87*	
				132.74
		2	*206677.61*	
				239.36
		3	*206916.97*	
$3p\,\,5s$	$^3P^\circ$	0	*209779.4*	
				152.7
		1	*209932.1*	
				771.5
		2	*210703.6*	

S IV $\qquad Z = 16$

13 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p\ ^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 47.08 volts

The classification has been given by Millikan and Bowen. They give the absolute value of the lowest state $3p\ ^2P_{\frac{1}{2}}$ as 381541.4 with respect to $3s^2\ ^1S_0$ of S V.

No intercombinations have been found between quartets and doublets.

References

R. A. Millikan and I. S. Bowen, *Phys. Rev.* **25**, 602 (1925).
I. S. Bowen, *Phys. Rev.* **31**, 38 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*0.0* *950.2*	950.2
$3s\ \ 3p^2$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	94101.9 94148.1	46.2
$3s\ \ 3p^2$	^2S	$\frac{1}{2}$	123503.9	
$3s\ \ 3p^2$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	133617.9 134243.9	626.0
$3s^2\ 3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	152127.1 152141.4	14.3
$3s^2\ 4s$	^2S	$\frac{1}{2}$	181432.2	
$3p^3$	$^2P^{\circ}$	$\frac{1}{2}$	*211358*	
$3s^2\ 4p$	$^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*213507.4* *213717.4*	210.0

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 4d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	255390.1	
$3s^2\ 5s$	^2S	$\frac{1}{2}$	271010.4	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\ 3p^2$	^4P	$\frac{1}{2}$	0.0	
		$1\frac{1}{2}$	345.0	345.0
		$2\frac{1}{2}$	889.7	544.7
$3p^3$	$^4S^\circ$	$1\frac{1}{2}$	*125271.6*	

S V $Z = 16$

12 electrons $1s^2\,2s^2\,2p^6\,3s^2\;{}^1S_0$

Ionization potential = 63 volts

This classification is taken from Millikan and Bowen. No intercombinations are known between singlets and triplets. The lowest triplet state has an absolute value of 501618 cm.$^{-1}$.

Reference

R. A. Millikan and I. S. Bowen, *Phys. Rev.* **25**, 591 (1925); **26**, 150 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2$	^1S	0	0	
$3s\ 3p$	$^1P^\circ$	1	*127144*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\ 3p$	$^3P^\circ$	0	*0.0*	
		1	*365.8*	365.8
		2	*1120.5*	754.7
$3p^2$	^3P	0	116573	
		1	117341	768
		2	118111	770
$3s\ 3d$	^3D	1, 2, 3	151918	
$3s\ 4s$	^3S	1	228543	
$3s\ 4p$	$^3P^\circ$	0	*266050*	
		1	*266138*	88
		2	*266427*	289

S VI $\qquad Z = 16$

11 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 87.65 volts

Millikan and Bowen give 710264 as the absolute value of the lowest state.

Reference

R. A. Millikan and I. S. Bowen, *Phys. Rev.* **25**, 295 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s$	^2S	$\frac{1}{2}$	0.0	
$3p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*105866.0* *107133.1*	1237.1
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	247409.8 247446.0	36.2
$4s$	^2S	$\frac{1}{2}$	363000.2	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*401180.7* *401638.3*	457.6
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*462652.1*	
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	552104.7	

Sb I $Z = 51$

51 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\, 5p^3\ {}^4S_{1\frac{1}{2}}$

Many levels of the arc spectrum of antimony were reported by Ruark, Mohler, Foote, and Chenault. The lowest levels can be assigned with some certainty but later assignments of the higher levels are very doubtful. Recently Löwenthal has added many new terms, but without classification.

References

A. E. Ruark, F. L. Mohler, P. D. Foote and R. L. Chenault, *Bur. Stand. Sci. Papers* **19**, 463 (1924).

J. C. McLennan and A. B. McLay, *Trans. Roy. Soc. Can.* **21**, 63 (1927).

J. B. Green and R. A. Loring, *Phys. Rev.* **31**, 707 (1928). Abstract.

S. L. Malurkar, *Proc. Camb. Phil. Soc.* **24**, 85 (1928).

H. Löwenthal, *Zeits. f. Physik* **57**, 828 (1929). Zeeman effect; hyperfine structure.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2\, 5p^3$	${}^4S^\circ$	$1\frac{1}{2}$	*0.0*	
$5s^2\, 5p^3$	${}^2D^\circ$	$1\frac{1}{2}$	*8511.9*	1341.6
		$2\frac{1}{2}$	*9853.5*	
$5s^2\, 5p^3$	${}^2P^\circ$	$\frac{1}{2}$	*16394.4*	2068.8
		$1\frac{1}{2}$	*18463.2*	
$5s^2\, 5p^2\, ({}^3P)\, 6s$	${}^4P$	$\frac{1}{2}$	43248.5	2696.0
		$1\frac{1}{2}$	45944.5	2387.4
		$2\frac{1}{2}$	48331.9	
$5s^2\, 5p^2\, ({}^3P)\, 6s$	${}^2P$	$\frac{1}{2}$	46990.1	2400.0
		$1\frac{1}{2}$	49390.1	

(*Concluded*)

Configuration	Symbol	*J*	Term value	
—	1	2½	53443	
	2	1½ ?	53527	
	3°	½ or 1½	*54194.7*	
	4	2½	55118	
	5°	½ or 1½	*55133.2*	
	6	1½	55231.7	
	7°	½ or 1½	*55308.2*	
	8	2½ ?	55727.7	
	9°	½ or 1½	*55862.8*	
	10°	½ or 1½	*55992.3*	
	11	1½	56150.9	
	12	½	56697	
	13	1½	56731.9	
	14°	2½	*57409.3*	
	15	½	57599	
	16°	1½	*58073.8*	
	17°	½	*58588.4*	
	18°	½	*58652.0*	
	19	1½	58745	
	20°	2½	*58833.7*	
	21	2½	58861	
	22	2½	60403	
	23	1½	60579	
	24°	½	*60999.2*	
	25	½	61385	
	26	1½	61806	
	27°	½ or 1½	*63899.3*	

Sb III $\qquad Z = 51$

49 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\, 5p\ {}^2P^\circ_{\frac{1}{2}}$

First ionization potential = 24.7 volts

This classification has been given according to Lang. The lowest state is given as 200272 cm.$^{-1}$.

Reference

R. J. Lang, *Phys. Rev.* **35**, 445 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2\ 5p$	${}^2P^\circ$	$\frac{1}{2}$	*0*	
		$1\frac{1}{2}$	*6576*	6756
$5s\ 5p^2$	${}^4P$	$\frac{1}{2}$	54366	
		$1\frac{1}{2}$	57962	3596
		$2\frac{1}{2}$	63320	5358
$5s\ 5p^2$	${}^2D$	$1\frac{1}{2}$	76528	
		$2\frac{1}{2}$	77798	1270
$5s^2\ 4f$	${}^2F^\circ$	$2\frac{1}{2}$	*81332* ?	
		$3\frac{1}{2}$	*81705* ?	373
$5s^2\ 6s$	${}^2S$	$\frac{1}{2}$	92951	
$5s\ 5p^2$	${}^2S$	$\frac{1}{2}$	93420	
$5s\ 5p^2$	${}^2P$	$\frac{1}{2}$	94648	
		$1\frac{1}{2}$	100040	5392
$5s^2\ 5d$	${}^2D$	$1\frac{1}{2}$	98822	
		$2\frac{1}{2}$	100389	1567
$5s^2\ 6p$	${}^2P^\circ$	$\frac{1}{2}$	*114722*	
		$1\frac{1}{2}$	*116390*	1668

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2\ 5f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*136217* *136272*	−55
$5s^2\ 7s$	^2S	$\frac{1}{2}$	143129	
$5s^2\ 6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	144683 144920	237
$5p^3$	$^4S^\circ$	$1\frac{1}{2}$	*149013*	
$5s^2\ 8s$	^2S	$\frac{1}{2}$	163390 ?	
$5s^2\ 5g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	164306	
$5s^2\ 6g$	^2G	$3\frac{1}{2}$, $4\frac{1}{2}$	174460 ?	

Sb IV $\qquad Z = 51$

48 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\ {}^1S_0$

First ionization potential = 44.0 volts

Gibbs and Vieweg, from whose paper these terms are taken, give the absolute value of the lowest state as 356156 cm.$^{-1}$.

Reference

R. C. Gibbs and A. M. Vieweg, *Phys. Rev.* **34,** 400 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	^1S	0	0	
$5s\ 5p$	$^3P^\circ$	0	*64435*	
				2265
		1	*66700*	
				5860
		2	*72560*	
$5s\ 5p$	$^1P^\circ$	1	*95952*	
$5p^2$	^3P	0	152070	
				4312
		1	156382	
				7135
		2	163517	
$5p^2$	^1D	2	155956	$5s\ 5d$?
$5s\ 6s$	^3S	1	188622	
$5s\ 5d$	^3D	1	178912	
				350
		2	179262	
				557
		3	179819	
$5s\ 5d$	^1D	2	182796	$5p^2$?
$5s\ 6p$	$^3P^\circ$	1	*215763*	
$5s\ 6p$	$^1P^\circ$	1	*219058*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\ 4f$	$^3F^\circ$	2	*227057*	85
		3	*227142*	160
		4	*227302*	
$5s\ 7s$	^3S	1	257771	
$5s\ 6d$	^3D	1	254656	170
		2	254826	249
		3	255075	
$5s\ 6d$	^1D	2	255571	

Sb V $Z = 51$

47 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s\ ^2S$

Ionization potential = 55.5 volts

The terms are given by Lang. The lowest state has an absolute value of 449300 cm.$^{-1}$.

Reference

R. J. LANG, *Proc. Nat. Acad. Sci.* **13,** 341 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s$	^2S	$\frac{1}{2}$	0	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*81566* *90554*	8988
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	201907 202736	829
$6s$	^2S	$\frac{1}{2}$	224587	
$4f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*268327*	

Sc I $Z = 21$

21 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d\ 4s^2\ {}^2D_{1\frac{1}{2}}$

First ionization potential $\doteq$ 6.7 volts

This classification is taken from Russell and Meggers. The absolute value of the lowest state is estimated by them to be about 54000 cm.$^{-1}$ with respect to $3d\ 4s\ {}^3D$ of Sc II.

Reference

H. N. Russell and W. F. Meggers, *Bur. Stand. Sci. Papers* **22**, 329 (1927)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4s^2$	^2D	$1\frac{1}{2}$	0.00	
				168.34
		$2\frac{1}{2}$	168.34	
$3d^2\ (^3F)\ 4s$	^4F	$1\frac{1}{2}$	11520.15	
				37.49
		$2\frac{1}{2}$	11557.64	
				52.60
		$3\frac{1}{2}$	11610.24	
				67.07
		$4\frac{1}{2}$	11677.31	
$3d^2\ (^3F)\ 4s$	^2F	$2\frac{1}{2}$	14926.24	
				115.74
		$3\frac{1}{2}$	15041.98	
$3d\ 4s\ (^3D)\ 4p$	$^4F^\circ$	$1\frac{1}{2}$	*15672.55*	
				83.96
		$2\frac{1}{2}$	*15756.51*	
				125.25
		$3\frac{1}{2}$	*15881.76*	
				144.76
		$4\frac{1}{2}$	*16026.52*	
$3d\ 4s\ (^3D)\ 4p$	$^4D^\circ$	$\frac{1}{2}$	*16009.71*	
				12.07
		$1\frac{1}{2}$	*16021.78*	
				119.26
		$2\frac{1}{2}$	*16141.04*	
				69.76
		$3\frac{1}{2}$	*16210.80*	
$3d\ 4s\ (^1D)\ 4p$	$^2D^\circ$	$2\frac{1}{2}$	*16022.72*	
				−74.14
		$1\frac{1}{2}$	*16096.86*	
$3d^2\ (^1D)\ 4s$	^2D	$2\frac{1}{2}$	17012.98	
				−12.38
		$1\frac{1}{2}$	17025.36	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4s\ (^3D)\ 4p$	$^4P°$	$\frac{1}{2}$	*18504.05*	
		$1\frac{1}{2}$	*18515.77*	11.72
		$2\frac{1}{2}$	*18571.40*	55.63
$3d\ 4s\ (^1D)\ 4p$	$^2P°$	$\frac{1}{2}$	*18711.03*	
		$1\frac{1}{2}$	*18855.76*	144.73
$3d^2\ (^1G)\ 4s$	^2G	$4\frac{1}{2}$	20237.10	
		$3\frac{1}{2}$	20239.92	−2.85
$3d\ 4s\ (^1D)\ 4p$	$^2F°$	$2\frac{1}{2}$	*21032.78*	
		$3\frac{1}{2}$	*21085.84*	53.06
$3d\ 4s\ (^3D)\ 4p$	$^2P°$	$\frac{1}{2}, 1\frac{1}{2}$	*24656.80*	
$3d\ 4s\ (^3D)\ 4p$	$^2D°$	$1\frac{1}{2}$	*24866.18*	
		$2\frac{1}{2}$	*25014.15*	147.97
$3d\ 4s\ (^3D)\ 4p$	$^2F°$	$2\frac{1}{2}$	*25584.64*	
		$1\frac{1}{2}$	*25724.72*	140.08
$3d^2\ (^3F)\ 4p$	$^4G°$	$2\frac{1}{2}$	*29022.87*	
		$3\frac{1}{2}$	*29096.20*	73.33
		$4\frac{1}{2}$	*29189.83*	93.63
		$5\frac{1}{2}$	*29303.52*	113.69
$3d^2\ (^1S)\ 4p$	$^2P°$	$\frac{1}{2}$	*30573.10*	
		$1\frac{1}{2}$	*30706.61*	133.51
$3d^2\ (^3F)\ 4p$	$^4F°$	$1\frac{1}{2}$	*31172.62*	
		$2\frac{1}{2}$	*31215.76*	43.14
		$3\frac{1}{2}$	*31275.32*	59.56
		$4\frac{1}{2}$	*31350.81*	75.49
$3d^2\ (^3F)\ 4p$	$^4D°$	$\frac{1}{2}$	*32637.40*	
		$1\frac{1}{2}$	*32659.21*	21.81
		$2\frac{1}{2}$	*32696.84*	37.63
		$3\frac{1}{2}$	*32751.54*	54.70
$3d^2\ (^3F)\ 4p$	$^2G°$	$3\frac{1}{2}$	*33056.19*	
		$4\frac{1}{2}$	*33151.40*	95.21
$3d^2\ (^3F)\ 4p$	$^2F°$	$2\frac{1}{2}$	*33154.01*	
		$3\frac{1}{2}$	*33278.64*	124.63

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3F)\ 4p$	$^2D^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$	*33615.06* *33707.25*	92.19
$3d^3$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	33763.57 33798.68 33846.62 33906.40	35.11 47.94 59.78
$3d\ 4s\ (^3D)\ 5s$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	34390.25 34422.85 34480.05 34567.10	32.60 57.20 87.05
$3d\ 4s\ (^3D)\ 5s$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	35671.00 35745.57	74.57
$3d^3$?	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	36276.76 36330.49	53.73
$3d^3$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	36492.82 36515.76 36572.80	22.94 57.04
$3d^2\ (^1D)\ 4p$	$^2D^\circ$	$1\frac{1}{2}$ $2\frac{1}{2}$	*36934.15* *37039.77*	105.62
$3d^2\ (^1D)\ 4p$	$^2P^\circ$	$1\frac{1}{2}$ $\frac{1}{2}$	*37086.31* *37125.72*	−39.41
$3d\ 4s\ (^3D)\ 4d$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	37085.72 37148.25	62.53
$3d\ 4s\ (^3D)\ 4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	37780.83 37855.50	74.67
$3d\ 4s\ (^3D)\ 4d$	^2G	$3\frac{1}{2}$ $4\frac{1}{2}$	38571.70 38658.23	86.53
$3d\ 4s\ (^3D)\ 4d$	^2F	$2\frac{1}{2}$ $3\frac{1}{2}$	38871.60 38959.16	87.56

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^1G)\ 4p$	$^2H^\circ$	$4\frac{1}{2}$	*39153.42*	95.85
		$5\frac{1}{2}$	*39249.27*	
$3d^2\ (^1G)\ 4p$	$^2G^\circ$	$3\frac{1}{2}$	*39392.95*	30.78
		$4\frac{1}{2}$	*39423.73*	
$3d\ 4s\ (^3D)\ 4d$	^4D	$\frac{1}{2}$	39701.30	20.41
		$1\frac{1}{2}$	39721.71	33.22
		$2\frac{1}{2}$	39754.93	44.92
		$3\frac{1}{2}$	39799.85	
$3d^2\ (^1G)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	*39881.25*	7.86
		$3\frac{1}{2}$	*39889.11*	
$3d\ 4s\ (^3D)\ 4d$	^4G	$2\frac{1}{2}$	39861.25	41.40
		$3\frac{1}{2}$	39902.65	55.06
		$4\frac{1}{2}$	39957.71	70.52
		$5\frac{1}{2}$	40028.23	
$3d\ 4s\ (^3D)\ 4d$	^4F	$1\frac{1}{2}$	40521.21	33.77
		$2\frac{1}{2}$	40554.98	49.04
		$3\frac{1}{2}$	40604.02	66.85
		$4\frac{1}{2}$	40670.87	
—	^2D	$1\frac{1}{2}$	40802.72	22.93
		$2\frac{1}{2}$	40825.65	
$3d^2\ (^3F)\ 5s$	^4F	$1\frac{1}{2}$	41921.94	38.92
		$2\frac{1}{2}$	41960.86	54.71
		$3\frac{1}{2}$	42015.57	69.44
		$4\frac{1}{2}$	42085.01	
—	^4D	$3\frac{1}{2}$	44598.80 ?	
$4p^2\ (^3P)\ 3d$	^4F	$1\frac{1}{2}$	44823.06	86.44
		$2\frac{1}{2}$	44909.50	106.87
		$3\frac{1}{2}$	45016.37	109.20
		$4\frac{1}{2}$	45125.57	
—	^4F	$1\frac{1}{2}$	47898.95	47.30
		$2\frac{1}{2}$	47946.25	125.52
		$3\frac{1}{2}$	48071.77	251.81
		$4\frac{1}{2}$	48323.58 ?	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3P)\ 4s$	^4P	$\frac{1}{2}$	0.00	
		$1\frac{1}{2}$	29.03	29.03
		$2\frac{1}{2}$	81.05	52.02
$3d^2\ (^3P)\ 4p$	$^4S^\circ$	$1\frac{1}{2}$	*20260.88*	
$3d^2\ (^3P)\ 4p$	$^4P^\circ$	$\frac{1}{2}$	*20651.73*	
		$1\frac{1}{2}$	*20682.48*	30.75
		$2\frac{1}{2}$	*20738.82*	56.34

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3P)\ 4s$	^2P	$\frac{1}{2}$	0.00	
		$1\frac{1}{2}$	80.40	80.40
$3d^2\ (^3P)\ 4p$	$^2D^\circ$	$1\frac{1}{2}$	*21766.52*	
		$2\frac{1}{2}$	*21820.74*	54.22
$3d^2\ (^3P)\ 4p$?	$^2S^\circ$	$\frac{1}{2}$	*21937.03*	
—	$^2D^\circ$	$1\frac{1}{2}$	*29831.50*	
		$2\frac{1}{2}$	*29929.54*	98.04

Sc II $\qquad Z = 21$

20 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d\,4s\ {}^3D_1$

First ionization potential = 12.8 volts

This classification has been given by Russell and Meggers. The lowest state is $3d\,4s\ {}^3D_1$ and its absolute value is about 104000 cm.$^{-1}$ with respect to $3d\ {}^2D$ of Sc III.

Reference

H. N. Russell, W. F. Meggers, *Bur. Stand. Sci. Papers* **22**, 329 (1927); *Bur. Stand. Journ. Res.* **2**, 733 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4s$	^3D	1	0.00	
		2	67.68	67.68
		3	177.63	109.95
$3d\ 4s$	^1D	2	2540.97	
$3d^2$	^3F	2	4802.75	
		3	4883.42	80.67
		4	4987.64	104.22
$3d^2$	^1D	2	10944.51	
$4s^2$	^1S	0	11736.35	
$3d^2$	^3P	0	12074.00	
		1	12101.45	27.45
		2	12154.34	52.89
$3d^2$	^1G	4	14261.40	
$3d\ 4p$	$^1D^\circ$	2	*26081.32*	
$3d\ 4p$	$^3F^\circ$	2	*27443.65*	
		3	*27602.32*	158.67
		4	*27841.17*	238.85

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4p$	$^3D^\circ$	1	*27917.69*	
				103.52
		2	*28021.21*	
				139.82
		3	*28161.03*	
$3d\ 4p$	$^3P^\circ$	0	*29736.22*	
				5.90
		1	*29742.12*	
				81.80
		2	*29823.92*	
$3d\ 4p$	$^1P^\circ$	1	*30815.65*	
$3d\ 4p$	$^1F^\circ$	3	*32349.98*	
$4s\ 4p$	$^3P^\circ$	0	*39001.59*	
				112.85
		1	*39114.44*	
				230.46
		2	*39344.90*	
$4s\ 4p$	$^1P^\circ$	1	*55715.52*	
$3d\ 5s$	^3D	1	57551.46	
				62.48
		2	57613.94	
				129.43
		3	57743.37	
$3d\ 5s$	^1D	2	58251.92	
$3d\ 4d$	^1F	3	59528.22	
$3d\ 4d$	^3D	1	59874.79	
				54.39
		2	59929.18	
				72.42
		3	60001.60	
$3d\ 4d$	^3G	3	60266.95	
				81.25
		4	60348.20	
				108.77
		5	60456.97	
$3d\ 4d$	^1P	1	60400.02	
$3d\ 4d$	^3S	1	61071.10	
$3d\ 4d$	^3F	2	63373.91	
				70.52
		3	63444.43	
				83.30
		4	63527.73	
$3d\ 4d$	^1D	2	67366.15	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4d$	^3P	0	64615.28	
				30.80
		1	64646.08	
				59.08
		2	64705.16	
$3d\ 4d$?	^1S	0	64942.79	
$3d\ 4d$	^1G	4	65235.83	
$4p^2$	^3P	0	76242.40	
				117.41
		1	76359.81	
				228.67
		2	76588.48	

Sc III $Z = 21$

19 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d\ ^2D_{1\frac{1}{2}}$

Ionization potential = 24.3 volts

These terms are taken from the work of Russell and Lang. The lowest state is $3d\ ^2D_{1\frac{1}{2}}$ and its absolute value is given as 199693 cm.$^{-1}$.

References

H. N. Russell and R. J. Lang, *Astrophys. Journ.* **66,** 13 (1927).
S. Smith, *Proc. Nat. Acad. Sci.* **13,** 65 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	0.0 197.5	197.5
$4s$	^2S	$\frac{1}{2}$	25536.7	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*62102.2* *62575.9*	473.7
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	112254.2 112299.2	45.0
$5s$	^2S	$\frac{1}{2}$	114863.8	
$4f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*136871.0*	

Se I $Z = 34$

34 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4d^{10}\ 4s^2\ 4p^4\ {}^3P_2$

Ionization potential = 9.5 volts

The terms in the first table can be found in Fowler and Paschen-Götze. They do not include the lowest state.

The terms in the second table, which contains the lowest state, have been taken from the work of McLennan, McLay, and McLeod.

By extrapolating the ${}^5S°$ series of the first table we obtained an approximate absolute value for $4p^3\ 5s\ {}^5S°$ of the second table, and found for the absolute value of the lowest state about 76600 cm. with respect to $4p^3\ {}^4S$ of SeII.

Reference

J. C. McLennan, A. B. McLay, and J. H. McLeod, *Phil. Mag.* **4**, 486 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^3\ ({}^4S)\ 5p$	${}^5P$	1	19416.2	
				44.8
		2	19371.4	
				113.7
		3	19267.7	
$6d$	${}^5D°$	0, 1, 2, 3, 4	*5112.5*	
$8s$	${}^5S°$	2	*4449.1*	
$7d$	${}^5D°$	0–4	*3462.1*	
$9s$	${}^5S°$	2	*3085.0*	
$8d$	${}^5D°$	0–4	*2498.2*	
$10s$	${}^5S°$	2	*2261.5*	
$9d$	${}^5D°$	0–4	*1887.9*	
$11s$	${}^5S°$	2	*1729.3*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^3(^4S)10d$	$^5D^\circ$	0–4	*1472.2*	
$11d$	$^5D^\circ$	0–4	*1184.3*	
$12d$	$^5D^\circ$	0–4	*973.2*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p^4$	^3P	2	0	
				−1990
		1	1990	
				−544
		0	2534	
$4p^3\ ^4S\ 5s$	$^5S^\circ$	2	*48187*	
$5s$	$^3S^\circ$	1	*51001*	
$4p^3\ 4d$	$^3D^\circ$	1	*61688?*	
				148
		2	*61836?*	
				407
		3	*62243?*	

Se III $Z = 34$

32 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^2\ {}^3P_0$

Several multiplets of the second spark spectrum of selenium have been classified by A. S. Rao. The multiplet involving the lowest state is incorrect, and this state therefore has not been given in this table.

Reference

A. S. Rao, *Zeits. f. Physik* **58,** 251 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4p\ 5s$	${}^3P^\circ$	0	*0*	
		1	*873*	873
		2	*3098*	2225
$4p\ 5p$	${}^3D$	1	26299	
		2	27582	1283
		3	29838	2256
$4p\ 5p$	${}^3S$	1	30032	
$4p\ 5p$	${}^3P$	1	30451	
		0	31651	
		2	33180	
$4p\ 5d$	${}^3F^\circ$	2	*54947*	
		3	*56016*	1069
		4	*57321*	1305
$4p\ 5d$	${}^3D^\circ$	1	*55205*	
		2	*55580*	375
		3	*57190*	1610
$4p\ 5d$	${}^3P^\circ$	0	*63545*	
		1	*64235*	690
		2	*65005*	770

Se V $Z = 34$

30 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ {}^1S_0$

This classification has been given by Sawyer and Humphreys in a study of the isoelectronic spectra.

The absolute value of $4s\,4p\ {}^3P_0^\circ$ is estimated to be 500000 cm.$^{-1}$. The lowest state has not been found.

Reference

R. A. Sawyer and C. J. Humphreys, *Phys. Rev.* **32**, 583 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s\ 4p$	${}^3P^\circ$	0	*0*	
				1595
		1	*1595*	
				3610
		2	*5205*	
$4s\ 4d$	${}^3D$	1	167778	
				214
		2	167992	
				335
		3	168327	
$4s\ 5s$	${}^3S$	1	197670	
$4p^2$	${}^3P$	0	122033	
				2295
		1	124328	
				4530
		2	128858	

Se VI $Z = 34$

29 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s\ ^2S_{\frac{1}{2}}$

Ionization potential = 81.4 volts

This classification is taken from Sawyer and Humphreys. The absolute value of the lowest state is 658,994 cm.$^{-1}$.

Reference

R. A. Sawyer and C. J. Humphreys, *Phys. Rev.* **32,** 583 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s$	^2S	$\frac{1}{2}$	0	
$4p$	$^2P^\circ$	$\frac{1}{2}$	*112762*	5700
		$1\frac{1}{2}$	*118462*	
$4d$	^2D	$1\frac{1}{2}$	282830	672
		$2\frac{1}{2}$	283509	
$5s$	^2S	$\frac{1}{2}$	333594	

Si I $\qquad Z = 14$

14 electrons $\qquad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^2\ {}^3P_0$

Ionization potential = 8.12 volts

The arc spectrum of silicon has been investigated and classified by Fowler. A few assignments are indicated by Fowler as doubtful.

Reference

A. Fowler, *Proc. Roy. Soc.* **A123,** 423 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3p^2$	^3P	0 1 2	65765.00 65687.94 65541.86	77.06 146.08
$3p^2$	^1D	2	59466.33	
$3p^2$	^1S	0	50370.90	
$3p\ 4s$	$^3P^\circ$	0 1 2	*26082.05* *26004.91* *25810.12*	77.14 194.79
$3p\ 4s$	$^1P^\circ$	1	*24773.40*	
$3p\ 4p$	^1D ?	2	22652	
$3s\ 3p^3$	$^3D^\circ$	1 2 3	*20488.94* *20471.89* *20443.54*	17.05 28.35
$3s\ 3p^3$	$^1D^\circ$	2	*18413.72*	
$3s^2\ 3p\ 4p$	^1S	0	15873	
$3s\ 3p^3$	$^3P^\circ$	2 1 0	*15265.5* *15199.2* *15163.2*	−66.3 −36.0

SILICON I

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\,3p\;3d$	$^1F^\circ$	3	*12403.61*	
$3p\;3d$	$^1P^\circ$	1	*12378.33*	
$3p\;3d$	$^3D^\circ$	1	*11580.2*	
				19.9
		2	*11560.3*	
				52.0
		3	*11508.3*	
$3p\;3d$	$^1D^\circ$	2	*11506.2*	
$3p\;5s$	$^3P^\circ$	0	*11520.5*	
				68.8
		1	*11451.7*	
				214.0
		2	*11237.7*	
$3p\;5s$	$^1P^\circ$	1	*10894.4*	
$3p\;3d$?	$^3P^\circ$?	0, 1, 2	*9262.8*	
$3p\;5p$?	$^3D^\circ$?	1	*8762.28*	
				14.56
		2	*8747.72*	
				180.54
		3	*8567.18*	
$3p\;5p$	^3P	0	8469.33	
				32.90
		1	8436.43	
				139.47
		2	8296.96	
$3p\;5p$	^1S	0	7967.23	
$3p\;4d$	$^1P^\circ$	1	*6963.0*	
$3p\;4d$	$^1F^\circ$	3	*6872.5*	
$3p\;4d$	$^3D^\circ$	1	*6788.8*	
				55.5
		2	*6733.3*	
				87.0
		3	*6646.3*	
$3p\;4d$	$^1D^\circ$	2	*6647.1*	
$3p\;6s$	$^3P^\circ$	0	*6544.3*	
				52.7
		1	*6491.6*	
				231.5
		2	*6260.1*	
$3p\;6s$	$^1P^\circ$	1	*6129.3*	

(*Concluded*)

Configuration	Symbol	J	Term value	
$3s^2\ 3p\ 4d$?	$^3P^\circ$?	0, 1, 2	*5755.3*	
$5d$?	$^1P^\circ$?	1	*4459.9*	
$5d$	$^1F^\circ$	3	*4341.6*	
$5d$	$^1D^\circ$	2	*4189*	
$7s$	$^1P^\circ$	1	*3885*	
$5d$?	$^3P^\circ$?	0, 1, 2	*3829*	
$6d$	$^1F^\circ$	3	*2997*	
—	1°	1	*2963*	
$6d$	$^1D^\circ$	2	*2817*	
$8s$	$^1P^\circ$	1	*2636*	
$7d$	$^1D^\circ$	2	*2008*	
$9s$	$^1P^\circ$	1	*1881*	

Si II $Z = 14$

13 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p\;{}^2P_{\frac{1}{2}}^{\circ}$

First ionization potential = 16.27 volts

This classification is given by Fowler and Bowen. The quartets found by Bowen have not been connected with the other terms.

References

A. Fowler, *Phil. Trans. Roy. Soc.* **A225,** 1 (1925).
I. S. Bowen and R. A. Millikan, *Phys. Rev.* **26,** 150 (1925).
I. S. Bowen, *Phys. Rev.* **31,** 34 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 3p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*131818* *131531*	287
$3s\ 3p^2$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	76514.1 76498.2	15.9
$3s^2\ 4s$	${}^2S$	$\frac{1}{2}$	66322.9	
$3s\ 3p^2$	${}^2S$	$\frac{1}{2}$	55154.1	
$3s^2\ 3d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	52483.1 52466.5	16.6
$4p$	${}^2P^{\circ}$	$\frac{1}{2}$ $1\frac{1}{2}$	*50632.0* *50572.0*	60.0
$3s\ 3p^2$	${}^2P$	$\frac{1}{2}$ $1\frac{1}{2}$	48018 47814	204
$3s^2\ 5s$	${}^2S$	$\frac{1}{2}$	33851.4	
$4d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	30800.4 30799.1	1.3

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2\ 4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*28265.4*	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*27962.7* *27938.4*	24.3
$6s$	^2S	$\frac{1}{2}$	20639.1	
$5d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	19428.8	
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*18061.4*	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*17769.3* *17760.2*	9.1
$7s$	^2S	$\frac{1}{2}$	13909.1	
$6d$	^2D	$1\frac{1}{2}, 2\frac{1}{2}$	13301.4	
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*12510.4*	

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\ 3p^2$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	0.0 107.9 283.3	107.9 175.4
$3p^3$	$^4S^\circ$	$1\frac{1}{2}$	*80208.5*	

Si III $Z = 14$

12 electrons $1s^2\,2s^2\,2p^6\,3s^2\;{}^1S_0$

Ionization potential = 33.35 volts

The classification given here is taken from the work of Fowler and of Sawyer and Paschen.

References

A. Fowler, *Trans. Roy. Soc.* **A225**, 1 (1925).
R. A. Sawyer and F. Paschen, *Ann. d. Physik* **84**, 1 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s^2$	^1S	0	270170	
$3s\ 3p$	$^3P^\circ$	0 1 2	*217273* *217139* *216890*	134 249
$3s\ 3p$	$^1P^\circ$	1	*187313*	
$3p^2$	^3P	0 1 2	140297 140166 139903	131 263
$3s\ 3d$	^3D	1 2 3	127093.00 127090.86 127088.85	2.14 2.01
$3s\ 4s$	^3S	1	116660	
$3s\ 4p$	$^3P^\circ$	0 1 2	*94806.57* *94773.55* *94700.39*	33.02 73.16
$3s\ 4d$	^3D	1, 2, 3	68438.08	
$3s\ 5s$	^3S	1	63861.01	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s\ 4f$	$^3F^\circ$	2	*60511.23*	
		3	*60483.44*	27.79
		4	*60444.00*	39.44
$3s\ 5f$	$^3F^\circ$	3	*39744* ?	
		4	*39584* ?	160
$3s\ 5g$	^3G	3, 4, 5	39741.21	
$3s\ 6g$	^3G	3, 4, 5	27568.82	

Si IV $\quad Z = 14$

11 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s\ {}^2S_{\frac{1}{2}}$

First ionization potential = 44.93 volts

These terms have been taken from the work of Fowler.

Reference

A. Fowler, *Phil. Trans. Roy. Soc.* **A225**, 1 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3s$	${}^2S$	$\frac{1}{2}$	364117	
$3p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*292837* *292377*	460
$3d$	${}^2D$	$1\frac{1}{2}, 2\frac{1}{2}$	203705	
$4s$	${}^2S$	$\frac{1}{2}$	170105	
$4p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*145817* *145655*	162
$4d$	${}^2D$	$1\frac{1}{2}, 2\frac{1}{2}$	114076	
$4f$	${}^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*109923*	
$5s$	${}^2S$	$\frac{1}{2}$	98666	
$5p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*87580* *87505*	75
$5d$	${}^2D$	$1\frac{1}{2}, 2\frac{1}{2}$	72594	
$5f$	${}^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*70366*	
$5g$	${}^2G$	$3\frac{1}{2}, 4\frac{1}{2}$	70213	
$6f$	${}^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*48862*	

(*Concluded*)

Configuration	Symbol	J	Term value	
$6g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	48780	
$6h$	$^2H^\circ$	$4\frac{1}{2}, 5\frac{1}{2}$	*48733*	
$7f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*35893*	
$7g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	35835	

Si V $Z = 14$

10 electrons $1s^2\,2s^2\,2p^6\;{}^1S_0$

Edlén and Ericson have identified two resonance lines of Si V in the far ultra-violet.

Reference

B. Edlén and A. Ericson, *Comptes Rendus* **190**, 116 (1930).

Configuration	Symbol	J	Term value
$3p^6$	^1S	0	0
$3p^5\,(^2P_{1\frac{1}{2}})\,4s$	$^3P^\circ$	1	*839405*
$3p^5\,(^2P_{\frac{1}{2}})\,4s$	$^1P^\circ$	1	*847350*

Sn I $\qquad$ $Z = 50$

50 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\, 5s^2\, 5p^2\ {}^3P_0$

Ionization potential = 7.30 volts

These terms have been taken from unpublished data of Randall and Wright. The g-values given in the last column were measured by Back. Due to overlapping it is impossible to separate the $5p\ 5d$ from the $5p\ 5s$ configuration.

References

E. Back, *Zeits. f. Physik* **43,** 309 (1927). Classification and Zeeman effect.
J. B. Green and R. A. Loring, *Phys. Rev.* **30,** 575 (1927).
H. M. Randall and N. Wright, unpublished data.

Configuration	Symbol	J	Term value	g-value
$5p^2$	^3P	0	59192.0	
		1	57500.0	1.501
		2	55764.0	1.452
	^1D	2	50578.5	1.050
	^1S	0	42029.0	
$5p\ (^2P_{\frac{1}{2}})\ 6s$	$^3P^\circ$	0	*24551.0*	
	$^3P^\circ$	1	*24277.5*	1.376
$5p\ (^2P_{1\frac{1}{2}})\ 6s$	$^3P^\circ$	2	*20563.0*	1.502
	$^1P^\circ$	1	*19934.7*	1.123
$5p\ (^2P_{\frac{1}{2}})\ 6p$	1	1	16851.0	
	2	0	15844.1	
	3	1	15825.0	
	4	2	15762.2	
$5p\ (^2P_{\frac{1}{2}})\ 5d$	1°	2	*15509.0*	0.865
	2°	2	*15047.5*	1.131
	3°	1	*14683.0*	0.635
	4°	3	*14616.0*	1.167

TIN I

(*Continued*)

Configuration	Symbol	J	Term value	g-value
$5p\ (^2P_{1\frac{1}{2}})\ 6p$	5	1	12588.4	
	6	3	12187.2?	
	7	2	11956.6	
	8	2	11386	
	9	0	11071.5?	
	10	1	11003.7	
$5p\ (^2P_{1\frac{1}{2}})\ 5d$ and $5p\ (^2P_{\frac{1}{2}})\ 7s$	5°	2	*12045*	0.941
	6°	3	*11704*	1.246
	7°	0	*10976*	
	8°	1	*10969.2*	1.316
	9°	2	*10522*	1.406
	10°	1	*10209*	1.229
	11°	3	*9297*	1.00
	12°	1	*9065*	1.066
$5p\ (^2P_{\frac{1}{2}})\ 7p$	1	1	8436.0	
	2	0	8347.6?	
	3	1	8078.5	
	4	2	8021.0	
$5p\ (^2P_{\frac{1}{2}})\ 6d$	1°	2	*8182*	
	2°	2	*8029*	
	3°	1	*7715*	0.863
	4°	3	*7437*	
$5p\ (^2P_{\frac{1}{2}})\ 4f$	1	3	6944	
	2	4	6937.7?	
	3	2	6926.5	
$5p\ (^2P_{1\frac{1}{2}})\ 7s$	$^3P°$	2	*6775*	
	$^1P°$	1	*6485*	
$5p\ (^2P_{\frac{1}{2}})\ 5f$	4	2	4424.0	
$5p\ (^2P_{1\frac{1}{2}})\ 4f$	5	2	2704.5	
—	13°	1	*6171*	
	14°	1, 2	*5558*	
	15°	1, 2, 3	*5363*	
	16°	1, 2, 3	*4539*	

(*Concluded*)

Configuration	Symbol	J	Term value	
—	17°	1	*4118*	
	18°	1	*4055*	
	19°	1	*4035*	
	20°	1	*3922*	
	21°	1	*3895*	
	22°	1	*3568*	
	23°	1	*3504*	
	24°	1	*3390*	
	25°	1	*2948*	
	26°	1, 2, 3	*2885*	
	27°	1	*2802*	
	28°	1, 2	*2648*	
	29°	1, 2, 3	*2613*	
	30°	1, 2	*2090*	
	31°	1, 2	*2038*	

Sn II $\qquad Z = 50$

49 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p\ ^2P^\circ_{\frac{1}{2}}$

Ionization potential = 14.5 volts

This classification has been taken from the papers mentioned below. The absolute value of the lowest state is about 117,700 cm.$^{-1}$.

References

J. B. Green and R. A. Loring, *Phys. Rev.* **30,** 574 (1927).
A. L. Narayan and K. R. Rao, *Zeits. f. Physik* **45,** 350 (1927).
R. J. Lang, *Phys. Rev.* **35,** 445 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2\ 5p$	$^2P^\circ$	$\frac{1}{2}$	*0*	
		$1\frac{1}{2}$	*4253*	4253
$5s\ 5p^2$	^4P	$\frac{1}{2}$	44508	
		$1\frac{1}{2}$	46462	1954
		$2\frac{1}{2}$	49494	3032
$5s^2\ 6s$	^2S	$\frac{1}{2}$	56883	
$5s\ 5p^2$	^2D	$1\frac{1}{2}$	58841	
		$2\frac{1}{2}$	59464	623
$5s^2\ 5d$	^2D	$1\frac{1}{2}$	71403	
		$2\frac{1}{2}$	72046	643
$5s^2\ 6p$	$^2P^\circ$	$\frac{1}{2}$	*71491*	
		$1\frac{1}{2}$	*72375*	884
$5s\ 5p^2$	^2S	$\frac{1}{2}$	81718	
$5s^2\ 7s$	^2S	$\frac{1}{2}$	86341	
$5s^2\ 5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*89288*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2\ 6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	90237 90344	107
$5s^2\ 7p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*92724* *93081*	357
$5s^2\ 8s$	^2S	$\frac{1}{2}$	96926	
$5s^2\ 6f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*99661*	
$5s^2\ 7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	100337 100377	40

Sn III $Z = 50$

48 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ {}^1S_0$

First ionization potential = 30.5 volts

This classification has been taken from the paper by Gibbs and Vieweg. The absolute value of the lowest state is 247302 cm.$^{-1}$ with respect to $5s\ {}^2S_{\frac{1}{2}}$ of Sn IV.

References

K. R. Rao, *Proc. London Phys. Soc.* **39**, 161 (1926).
J. B. Green and R. A. Loring, *Phys. Rev.* **30**, 574 (1927).
R. C. Gibbs and A. M. Vieweg, *Phys. Rev.* **34**, 400 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	^1S	0	0	
$5s\ 5p$	$^3P^\circ$	0	*53544*	
		1	*55191*	1647
		2	*59225*	4034
	$^1P^\circ$	1	*79908*	
$5p^2$	^3P	0	127302	
		1	130112	2810
		2	134559	4447
	^1D	2	128196	
$5s\ 6s$	^3S	1	139630	
$5s\ 5d$	^3D	1	141313	
		2	141519	206
		3	141832	313
	^1D	2	143585	
$5s\ 6p$	$^3P^\circ$	0	*159933*	
		1	*160209*	276
		2	*161433*	1224

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\ 6p$	$^1P^\circ$	1	*162721*	
$5s\ 4f$	$^3F^\circ$	2	*179298*	
		3	*179335*	37
		4	*179434*	99
	$^1F^\circ$	3	*181760*	
$5s\ 7s$	^3S	1	186677	
$5s\ 6d$	^3D	1	187908	
		2	187991	83
		3	188127	136
	^1D	2	189687	
$5s\ 5f$	$^3F^\circ$	2	*202398*	
		3	*202408*	10
		4	*202436*	28
	$^1F^\circ$	3	*203624*	
$5s\ 5g$	^3G	3, 4, 5	204076	
	^1G	4	204102	
—	1	—	204397	

Sn IV $\quad Z = 50$

47 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 39.4 volts

These terms are taken from the paper by Rao, Narayan, and Rao. The lowest state is given as 328671 cm.$^{-1}$ by setting $6g\ {}^2G$ at 70400.

References

R. J. Lang, Proc. Nat. Acad. Sci. **13**, 341 (1927).

K. R. Rao, A. L. Narayan, and A. S. Rao, *Indian Journ. Phys.* **2**, 476 (1928).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s$	^2S	$\frac{1}{2}$	0	
$5p$	$^2P^\circ$	$\frac{1}{2}$	*69559*	6518
		$1\frac{1}{2}$	*76077*	
$4f$	$^2F^\circ$	$2\frac{1}{2}$	*117428*	12
		$3\frac{1}{2}$	*117440*	
$5d$	^2D	$1\frac{1}{2}$	165297	207
		$2\frac{1}{2}$	165404	
$6s$	^2S	$\frac{1}{2}$	174131	
$6p$	$^2P^\circ$	$\frac{1}{2}$	*197845*	2177
		$1\frac{1}{2}$	*200022*	
$5f$	$^2F^\circ$	$2\frac{1}{2}$	*213260*	165
		$3\frac{1}{2}$	*213425*	
$6d$	^2D	$1\frac{1}{2}$	234786	332
		$2\frac{1}{2}$	235118	
$7s$	^2S	$\frac{1}{2}$	237608	
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*253678*	
$6g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	258271	

Sn V $\qquad\qquad$ $Z = 50$

46 electrons $\qquad$ $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d^{10}\ {}^1S_0$

Ionization potential = 58 volts

This classification has been given by Gibbs and White. The absolute value of the lowest state is about 470000 cm.$^{-1}$ with respect to $4d^9\ {}^2D$ of Sn VI.

Reference

R. C. Gibbs and H. E. White, *Proc. Nat. Acad. Sci.* **14**, 345 (1928).

Configuration	Symbol	J	Term value	
$4d^{10}$	^1S	0	0	
$4d^9\ (^2D_{2\frac{1}{2}})\ 5s$	1	3	182586	$^3D_3$
	2	2	185064	$^3D_2$
$4d^9\ (^2D_{1\frac{1}{2}})\ 5s$	3	1	191206	$^3D_1$
	4	2	194231	$^1D_2$
$4d^9\ (^2D)\ 5p$	1°	2	*259377*	
	2°	3	*262322*	
	3°	1	*267997*	
	4°	4	*268733*	
	5°	2	*269098*	
	6°	0	*273293*	
	7°	2	*273335*	
	8°	3	*274379*	
	9°	1	*276590*	
	10°	3	*279242*	
	11°	1	*281165*	
	12°	2	*282615*	

Sr I $\qquad$ $Z = 38$

38 electrons $\qquad$ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 5s^2\ {}^1S_0$

First ionization potential = 5.667 volts

These terms of the arc spectrum of strontium are from the work of Russell and Saunders. The regular series terms may also be found in Fowler and Paschen-Götze. All terms have absolute values given with respect to the $5s\ {}^2S_{\frac{1}{2}}$ of Sr II as zero. There are many terms, however, which are due to two excited electrons, and do not converge to the same limit.

The first table contains all terms, the other tables those terms based on $5s\ {}^2S_{\frac{1}{2}}$ which belong together in series.

References

F. A. Saunders, *Astrophys. Journ.* **56**, 73 (1922).
H. N. Russell and F. A. Saunders, *Astrophys. Journ.* **61**, 39 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	${}^1S$	0	45925.6	
$5s\ 5p$	${}^3P^\circ$	0	*31608.0*	
				186.8
		1	*31421.2*	
				394.2
		2	*31027.0*	
$5s\ 4d$	${}^3D$	1	27766.0	
				59.6
		2	27706.4	
				100.4
		3	27606.0	
$5s\ 4d$	${}^1D$	2	25776.3	
$5s\ 5p$	${}^1P^\circ$	1	*24227.1*	
$5s\ 6s$	${}^3S$	1	16886.8	
$5s\ 6s$	${}^1S$	0	15334.5	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\,5p$	$^3F^\circ$	2 3 4	*12658.5* *12335.7* *12006.0*	322.8 329.7
—	1	2	12098.1	
$5s\,6p$	$^3P^\circ$	0 1 2	*12098.8* *12057.4* *11952.8*	41.4 104.6
$5s\,6p$	$^1P^\circ$	1	*11827.5*	
$5s\,5d$	^1D	2	11110.0	
$5s\,5d$	^3D	1 2 3	10918.3 10903.3 10880.5	15.0 22.8
$4d^2$	^3P	0 1 2	10731.8 10525.5 10250.7	206.3 274.8
—	2°	2 or 3	*9836.1*	
$4d\,5p$	$^3D^\circ$	1 2 3	*9661.2* *9543.4* *9365.9*	117.8 177.5
	3 4	1 or 2 0 or 1	8964.6 8765.2	
$4d\,5p$	$^3P^\circ$	0 1 2	*8633.0* *8622.2* *8588.5*	10.8 33.7
$5s\,7s$	^3S	1	8500.9	
—	5°	2 or 3	*7917.2*	
$5s\,7s$	^1S	0	7481.6	
$5s\,4f$	$^3F^\circ$	2 3 4	*7174.6* *7172.9* *7170.2*	1.7 2.7

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\,7p$	$^1P^\circ$	1	*7019.0*	
$5s\,7p$	$^3P^\circ$	0 1 2	*6514.2* *6499.2* *6468.1*	14.8 31.1
$5s\,4f$	$^1F^\circ$	3	*6387.0*	
$5s\,6d$	^3D	1 2 3	6239.4 6234.5 6222.2	4.9 12.3
$5s\,6d$	^1D	2	6192.4	
$5s\,8s$	^3S	1	5163.2	
$5s\,8s$	^1S	0	4873.1	
$5s\,8p$	$^1P^\circ$	1	*4753.5*	
$5s\,5f$	$^3F^\circ$	2 3 4	*4560.4* *4559.6* *4558.7*	0.8 0.9
$5s\,5f$	$^1F^\circ$	3	*4406.9*	
$5s\,7d$	^1D	2	4093.7	
$5s\,7d$	^3D	1 2 3	4061.1 4056.5 4051.0	4.6 5.5
$5s\,9s$	^3S	1	3473.4	
$5s\,9p$	$^1P^\circ$	1	*3463.4*	
$5s\,9s$	^1S	0	3329.6	
$5s\,6f$	$^3F^\circ$	2 3 4	*3149.5* *3148.9* *3148.0*	0.6 0.9
$5s\,6f$	$^1F^\circ$	3	*3086.8*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\ 8d$	^1D	2	2904.7	
$5s\ 8d$	^3D	1 2 3	2858.7 2855.1 2850.6	3.6 4.5
$5s\ 10p$	$^1P°$	1	*2598.8*	
$5s\ 10s$	^3S	1	2498.4	
$5s\ 10s$	^1S	0	2412.8	
$5s\ 7f$	$^3F°$	2 3 4	*2303.5* *2301.6* *2301.1*	1.9 0.5
$5s\ 7f$	$^1F°$	3	*2269.9*	
$5s\ 9d$	^1D	2	2145.0	
$5s\ 9d$	^3D	1 2 3	2123.7 2120.5 2116.4	3.2 4.1
$5s\ 11p$	$^1P°$	1	*1989.2*	
$5s\ 11s$	^3S	1	1882.0	
$5s\ 11s$	^1S	0	1828.3	
$5s\ 8f$	$^3F°$	2, 3, 4	*1753.5*	
$5s\ 8f$	$^1F°$	3	*1735.8*	
$5s\ 10d$	^3D	1 2 3	1641.7 1638.4 1634.0	3.3 4.4
$5s\ 12p$	$^1P°$	1	*1559.8*	
$5s\ 12s$	^3S	1	1467.7	
$5p^2$	^3P	0 1 2	1399.8 1329.6 1195.9	70.2 133.7

STRONTIUM I

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s\,9f$	$^3F°$	2, 3, 4	*1380.5*	
$5s\,9f$	$^1F°$	3	*1370.0*	
$5s\,11d$	^3D	1, 2 3	1307.0 1300.3	
$5s\,13p$	$^1P°$	1	*1251.0*	
$5s\,10f$	$^3F°$	2, 3, 4	*1115.3*	
$5s\,10f$	$^1F°$	3	*1106.9*	
$5s\,12d$	^3D	1, 2 3	1065.4 1060.5	
$5s\,14p$	$^1P°$	1	*1022.0*	
$5s\,11f$	$^3F°$	2, 3, 4	*919.7*	
$5s\,11f$	$^1F°$	3	*913.7*	
$5s\,13d$	^3D	1, 2, 3	881.5	
$5s\,12f$	$^3F°$	2, 3, 4	*769.6*	
$5s\,12f$	$^1F°$	3	*765.6*	
$5s\,13f$	$^3F°$	2, 3, 4	*651.2*	
$5s\,13f$	$^1F°$	3	*648.1*	
$5s\,15d$	^3D	1, 2, 3	638.0	
$5s\,16d$	^3D	1, 2, 3	552.8	
$4d\,6p$	$^3F°$	2 3 4	*−3473.3* *−3621.6* *−3729.4*	148.3 107.8

SERIES

$5s\,ms$		
m	$^3S_1$	$^1S_0$
5		45925.6
6	16886.8	15334.5
7	8500.9	7481.6
8	5163.2	4873.1
9	3473.4	3329.6
10	2498.0	2412.8
11	1882.0	1828.3
12	1467.7	

$5s\,mp$				
m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	$^1P_1^\circ$
5	*31608.0*	*31421.2*	*31027.0*	*24227.1*
6	*12098.8*	*12057.4*	*11952.8*	*11827.5*
7	*6514.0*	*6499.2*	*6468.1*	*7019.0*
8				*4753.5*
9				*3463.4*
10				*2598.8*
11				*1989.2*
12				*1559.8*
13				*1251.0*
14				*1022.0*

$5s\,md$				
m	$^3D_1$	$^3D_2$	$^3D_3$	$^1D_2$
4	27766.0	27706.4	27606.0	25776.3
5	10918.3	10903.3	10880.5	11110.0
6	6239.4	6234.5	6222.2	6192.4
7	4061.1	4056.5	4051.0	4093.7
8	2858.7	2855.1	2850.6	2904.7
9	2123.7	2120.5	2116.4	2145.0
10	1641.7	1638.4	1634.0	
11	1307.0	1300.3		
12	1065.4	1060.5		
13		—		
14		881.5		
15		638.0		
16		552.8		

(*Concluded*)

5s mf				
m	$^3F_2^\circ$	$^3F_3^\circ$	$^3F_4^\circ$	$^1F_3^\circ$
4	*7174.6*	*7172.9*	*7170.2*	*6387.0*
5	*4560.4*	*4559.6*	*4558.7*	*4406.9*
6	*3149.5*	*3148.9*	*3148.0*	*3086.8*
7	*2303.5*	*2301.6*	*2301.1*	*2269.9*
8		*1753.5*		*1735.8*
9		*1380.5*		*1370.0*
10		*1115.3*		*1106.9*
11		*919.7*		*913.9*
12		*769.6*		*765.6*
13		*651.2*		*648.1*

Sr II $\qquad Z = 38$

37 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,5s\ {}^2S_{\frac{1}{2}}$

Ionization potential = 10.98 volts

The classification has been taken from Fowler and Paschen-Götze.

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s$	^2S	$\frac{1}{2}$	88952.47	
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	74395.66 72115.60	279.62
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*65237.26* *64435.80*	801.46
$6s$	^2S	$\frac{1}{2}$	41215.99	
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	35666.20 35580.59	85.61
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*27960.4*	
$7s$	^2S	$\frac{1}{2}$	23988.79	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	21429.98 21389.94	40.04
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*17896*	
$8s$	^2S	$\frac{1}{2}$	15712.56	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	14330.8 14309.5	21.3
$6f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*12412*	
$8d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	10293 10290	3
$7f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*9096*	

Te I $\qquad$ $Z = 52$

52 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^4\ {}^3P_2$

McLennan, McLay, and McLeod have classified several lines in the arc spectrum of tellurium. Only the two low odd terms have been assigned to a configuration and the rest is numbered. The low ^3P is partially inverted due to deviation from Russell-Saunders coupling.

Reference

J. C. McLennan, A. B. McLay, and J. H. McLeod, *Phil. Mag.* **4,** 486 (1927); *Nature* **124,** 874 (1929).

Configuration	Symbol	J	Term value
$5s^2\ 5p^4$	^3P	2	0
		0	4706.7
		1	4751.0
$5s^2\ 5p^4$	^1D	2	10558.6
$5s^2\ 5p^4$	^1S	0	23199
$5s^2\ 5p^3\ 6s$	$^5S°$	2	*44253.4*
$5s^2\ 5p^3\ 6s$	$^3S°$	1	*46653.6*
—	1°	1	*54684.9*
	2°	2	*54881.1*
	3°	2	*55818.9*
	4°	2	*57116.4*
	5°	2	*58596.4*
	6°	3	*58832*

Te V $\qquad Z = 52$

48 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ {}^1S_0$

First ionization potential = 60.0 volts

This classification has been given by Gibbs and Vieweg. The absolute value of the lowest state is 486244 cm.$^{-1}$.

Reference

R. C. Gibbs and A. M. Vieweg, *Phys. Rev.* **34**, 400 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	^1S	0	0	
$5s\ 5p$	$^3P^\circ$	0	*75109*	
				2914
		1	*78023*	
				7974
		2	*85997*	
	$^1P^\circ$	1	*111707*	
$5p^2$	^3P	0	176248	
				6171
		1	182419	
				10173
		2	192592	
	^1D	2	182797	
$5s\ 5d$	^3D	1	215612	
				525
		2	216137	
				972
		3	217109	
	^1D	2	221493	
$5s\ 6s$	^3S	1	240837	

Te VI $\qquad\qquad Z = 52$

47 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s\ ^2S_{\frac{1}{2}}$

Lang has located the principal doublet of this spectrum.

Reference

R. J. Lang, *Proc. Nat. Acad. Sci.* **13**, 341 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s$	^2S	$\frac{1}{2}$	0	
$5p$	$^2P^\circ$	$\frac{1}{2}$	*92772*	11988
		$1\frac{1}{2}$	*104760*	

Ti I $Z = 22$

22 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^2\,4s^2\;{}^3F_2$

First ionization potential = 6.81 volts

The arc spectrum of titanium is one of the most completely analyzed of the complex spectra. It has been classified by Russell. Nearly all the terms from the configurations $3d^2\,4s^2$, $3d^3\,4s$, $3d^2\,4s\,4p$, and $3d^3\,4p$ have been found. The absolute value of the lowest state is 55138 with respect to $3d^2\,4s\;{}^4F_{1\frac{1}{2}}$ of Ti II.

References

H. N. Russell, *Astrophys. Journ.* **66**, 347 (1927).

G. R. Harrison, *Journ. Opt. Soc. Am.* **17**, 389 (1928); **19**, 109 (1929). Intensities.

G. R. Harrison and H. Engwicht, *Journ. Opt. Soc. Am.* **18**, 287 (1929) Intensities.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\,4s^2$	^3F	2	0.00	
				170.14
		3	170.14	
				216.74
		4	386.88	
$3d^3\,(^4F)\,4s$	^5F	1	6556.86	
				41.97
		2	6598.83	
				62.17
		3	6661.00	
				81.79
		4	6742.79	
				100.21
		5	6843.00	
$3d^2\,4s^2$	^1D	2	7255.29	
$3d^2\,4s^2$	^3P	0	8436.69	
				55.79
		1	8492.48	
				109.94
		2	8602.42	
$3d^3\,(^4F)\,4s$	^3F	2	11531.82	
				108.03
		3	11639.85	
				137.04
		4	11776.89	
$3d^2\,4s^2$	^1G	4	12118.46	

TITANIUM I

(*Continued*)

Configuration	Symbol	*J*	Term value	Δν
$3d^3\ (^4P)\ 4s$	^5P	1	13981.75	
		2	14028.47	46.72
		3	14105.68	77.21
$3d^3\ (^2G)\ 4s$	^3G	3	15108.12	
		4	15156.83	48.71
		5	15220.47	63.64
$3d^2\ 4s^2$	^1S	0	15166.59	
$3d^2\ 4s\ (^4F)\ 4p$	$^5G^\circ$	2	*15877.18*	
		3	*15975.59*	98.41
		4	*16106.08*	130.49
		5	*16267.51*	161.43
		6	*16458.71*	191.20
$3d^2\ 4s\ (^4F)\ 4p$	$^5F^\circ$	1	*16817.19*	
		2	*16875.19*	58.00
		3	*16961.42*	86.23
		4	*17075.31*	113.89
		5	*17215.44*	140.13
$3d^3\ (^2D)\ 4s$	^3D	1	17369.59	
		2	17424.11	54.52
		3	17540.33	116.22
$3d^3\ (^2P)\ 4s$	^3P	0	17995.75	
		1	18061.54	65.79
		2	18145.40	83.86
$3d^3\ (^2H)\ 4s$	^3H	4	18037.28	
		5	18141.37	104.09
		6	18192.66	51.29
$3d^3\ (^2G)\ 4s$	^1G	4	18287.62	
$3d^2\ 4s\ (^4F)\ 4p$	$^5D^\circ$	0	*18462.83*	
		1	*18482.86*	20.03
		2	*18525.07*	42.21
		3	*18593.99*	68.92
		4	*18695.23*	101.24
$3d^3\ (^4P)\ 4s$	^3P	0	18818.23	
		1	18825.89	7.66
		2	18911.55	85.66

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\,4s\,(^2F)\,4p$	$^3F°$	2	*19322.98*	
		3	*19421.60*	98.62
		4	*19573.96*	152.36
$3d^2\,4s\,(^2F)\,4p$	$^3D°$	1	*19937.88*	
		2	*20006.08*	68.20
		3	*20126.13*	120.05
$3d^3\,(^2P)\,4s$	^1P	1	20062.98	
$3d^3\,(^2D)\,4s$	^1D	2	20209.64	
$3d^3\,(^2H)\,4s$	^1H	5	20795.65	
$3d^2\,4s\,(^2F)\,4p$	$^3G°$	3	*21469.53*	
		4	*21588.46*	118.93
		5	*21739.69*	151.23
$3d^2\,4s\,(^2F)\,4p$	$^1D°$	2	*22081.15*	
$3d^2\,4s\,(^2F)\,4p$	$^1F°$	3	*22404.69*	
$3d^2\,4s\,(^2F)\,4p$	$^1G°$	4	*24694.81*	
$3d^2\,4s\,(^2P)\,4p$	$^3S°$	1	*24921.19*	
$3d^2\,4s\,(^4P)\,4p$	$^5S°$	2	*25102.88*	
$3d^2\,4s\,(^4F)\,4p$	$^3F'°$	2	*25107.44*	
		3	*25227.26*	119.82
		4	*25388.39*	161.13
$3d^2\,4s\,(^4F)\,4p$	$^3D°$	1	*25317.88*	
		2	*25439.04*	121.6
		3	*25643.76*	204.72
$3d^2\,4s\,(^2P)\,4p$	$^3P°$	2	*25493.78*	
		1	*25537.39*	−43.61
$3d^2\,4s\,(^4P)\,4p$	$^5D°$	0	*25605.03*	
		1	*25635.74*	30.71
		2	*25699.95*	64.21
		3	*25797.60*	97.65
		4	*25926.82*	129.22

(*Continued*)

Configuration	Symbol	J	Term value	Δν
$3d^3\,(^4F)\,4p$	$^5G°$	2	*26494.37*	70.06
		3	*26564.43*	92.98
		4	*26657.41*	115.57
		5	*26772.98*	137.71
		6	*26910.69*	
$3d^3\,(^4F)\,4p$	$^3F°$	2	*26803.48*	89.52
		3	*26893.00*	132.66
		4	*27025.66*	
$3d^2\,4s\,(^2P)\,4p$	$^3D°$	1	*27355.16*	62.94
		2	*27418.10*	62.04
		3	*27480.14*	
$3d^3\,(^4F)\,4p$	$^3G°$	3	*27498.91*	115.80
		4	*27614.71*	135.45
		5	*27750.16*	
$3d^2\,4s\,(^4P)\,4p$	$^5P°$	1	*27665.57*	74.62
		2	*27740.19*	147.55
		3	*27887.74*	
$3d^2\,4s\,(^2D)\,4p$	$^1D°$	2	*27906.91*	
$3d^3\,(^4F)\,4p$	$^5F°$	1	*28596.45*	42.37
		2	*28638.82*	63.88
		3	*28702.70*	85.69
		4	*28788.39*	107.69
		5	*28896.08*	
$3d^3\,(^4F)\,4p$	$^3D°$	1	*29661.26*	107.44
		2	*29768.70*	143.63
		3	*29912.33*	
$3d^3\,(^2F)\,4s$	^1F	3	29818.31	
$3d^3\,(^4F)\,4p$	$^5D°$	0	*29829.16*	26.10
		1	*29855.26*	52.03
		2	*29907.29*	78.95
		3	*29986.24*	74.10
		4	*30060.34*	
$3d^2\,4s\,(^4F)\,4p$	$^3G°$	3	*29914.79*	56.34
		4	*29971.13*	68.22
		5	*30039.35*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\,4s\,(^2D)\,4p$	$^3D^\circ$	1	*31184.01*	
				6.71
		2	*31190.72*	
				15.36
		3	*31206.08*	
$3d^2\,4s\,(^2G)\,4p$	$^3G^\circ$	3	*31373.85*	
				115.64
		4	*31489.49*	
				139.27
		5	*31628.76*	
$3d^2\,4s\,(^2D)\,4p$	$^3P^\circ$	0	*31685.90*	
				39.85
		1	*31725.75*	
				80.19
		2	*31805.94*	
$3d^2\,4s\,(^2G)\,4p$	$^3H^\circ$	4	*31829.98*	
				84.33
		5	*31914.31*	
				99.30
		6	*32013.61*	
$3d^3\,(^2G)\,4p$	$^1F^\circ$	3	*32857.76*	
$3d^2\,4s\,(^4P)\,4p$	$^3P^\circ$	0	*33085.14*	
				5.41
		1	*33090.55*	
				23.94
		2	*33114.49*	
$3d^2\,4s\,(^2D)\,4p$	$^1P^\circ$	1	*33660.73*	
$3d^2\,4s\,(^2D)\,4p$	$^3F^\circ$	2	*33655.97*	
				24.35
		3	*33680.32*	
				20.55
		4	*33700.87*	
$3d^2\,4s\,(^2G)\,4p$	$^3F^\circ$	2	*33980.63*	
				98.02
		3	*34078.65*	
				126.41
		4	*34205.06*	
$3d^3\,(^2G)\,4p$	$^1H^\circ$	5	*34700.31*	
$3d^2\,4s\,(^2P)\,4p$	$^1P^\circ$	1	*34947.02*	
$3d^2\,4s\,(^2P)\,4p$	$^1D^\circ$	2	*35035.11*	
$3d^2\,4s\,(^4P)\,4p$	$^3S^\circ$	1	*35439.43*	
$3d^3\,(^2G)\,4p$	$^3H^\circ$	4	*35453.99*	
				105.67
		5	*35559.66*	
				125.57
		6	*35685.23*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\,(^4P)\,4p$	$^5D^\circ$	0	*35503.40*	
		1	*35527.76*	24.36
		2	*35577.14*	49.38
		3	*35652.95*	75.81
		4	*35757.51*	104.56
$3d^2\,4s\,(^4F)\,5s$	^5F	1	35959.07	
		2	36013.57	54.50
		3	36096.47	82.90
		4	36208.92	112.45
		5	36351.43	142.51
$3d^3\,(^2G)\,4p$	$^1G^\circ$	4	*36000.25*	
$3d^4$	^3G	3	36065.75	
		4	36132.31	66.46
		5	36200.94	68.73
$3d^3\,(^4P)\,4p$	$^5P^\circ$	1	*36298.43*	
		2	*36340.67*	42.24
		3	*36414.58*	73.91
$3d^3\,(^4P)\,4p$	$^3P^\circ$	0	*37090.65*	
		1	*37173.03*	82.38
		2	*37325.47*	152.44
$3d^3\,(^4P)\,4p$	$^5S^\circ$	2	*37359.13*	
$3d^2\,4s\,(^4F)\,5s$	^3F	2	37538.71	
		3	37659.97	121.26
		4	37824.69	164.72
$3d^3\,(^2G)\,4p$	$^3G^\circ$	3	*37554.99*	
		4	*37617.93*	62.94
		5	*37690.37*	72.44
$3d^2\,4s\,(^2D)\,4p$	$^1F^\circ$	3	*37622.63*	
$3d^3\,(^2D)\,4p$	$^3F^\circ$	2	*37654.77*	
		3	*37743.96*	89.19
		4	*37852.47*	108.51
$3d^2\,4s\,(^4P)\,4p$	$^3D^\circ$	1	*37851.91*	
		2	*37976.78*	124.87
		3	*38159.71*	182.93

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\ (^2P)\ 4p$	$^1S^\circ$	0	*38200.94*	
$3d^3\ (^2G)\ 4p$	$^3F^\circ$	2 3 4	*38451.29* *38544.38* *38670.73*	93.09 126.35
$3d^3\ (^2H)\ 4p$	$^3I^\circ$	5 6 7	*38572.75* *38669.03* *38779.97*	96.28 110.94
$3d^3\ (^2F)\ 4p$	$^3D^\circ$	1 2 3	*38654.23* *38699.95* *38764.96*	45.72 65.01
$3d^2\ 4s\ (^2G)\ 4p$	$^1G^\circ$	4	*38959.53*	
$3d^3\ (^2D)\ 4p$	$^1P^\circ$	1	*39078.00*	
$3d^3\ (^4F)\ 5s$	^5F	1 2 3 4 5	39107.25 39149.26 39214.38 39302.36 39412.78	42.01 65.12 87.98 110.42
$3d^3\ (^2H)\ 4p$	$^3H^\circ$	4 5 6	*39115.99* *39152.14* *39198.39*	36.15 46.25
$3d^3\ (^2P)\ 4p$	$^1P^\circ$	1	*39265.80*	
$3d^2\ 4s\ \ (^2F)\ 5s$	^3F	2 3 4	39526.89 39640.98 39785.94	114.09 144.96
$3d^3\ (^4P)\ 4p$	$^3D^\circ$	1 2 3	*39662.15* *39686.10* *39715.51*	23.95 29.41
$3d^3\ (^2D)\ 4p$	$^1F^\circ$	3	*40303.04*	
$3d^3\ (^2H)\ 4p$	$^1I^\circ$	5	*40319.80*	
$3d^3\ (^2D)\ 4p$	$^3P^\circ$	0 1 2	*40369.76* *40384.58* *40467.04*	14.82 82.46

(*Continued*)

Configuration	Symbol	J	Term value	Δν
$3d^3$ (^2P) $4p$	$^3D°$	1	*40556.07*	114.53
		2	*40670.60*	173.59
		3	*40844.19*	
$3d^3$ (^4P) $4p$	$^3S°$	1	*40844.19*	
—	$^1G°$	4	*40883.30 ?*	
$3d^3$ (^2H) $4p$	$^1H°$	5	*41039.93*	
$3d^2\,4s$ (^2F) $5s$	^1F	3	41087.31	
$3d^3$ (^2H) $4p$	$^3G°$	3	*41169.82*	85.62
		4	*41255.44*	86.18
		5	*41341.62*	
$3d^2\,4s$ (^4F) $4d$	^3G	3	41194.42	174.44
		4	41368.86	112.27
		5	41481.13	
$3d^3$ (^2F) $4p$	$^3F°$	2	*41337.43*	120.19
		3	*41457.62*	166.51
		4	*41624.13*	
$3d^2\,4s$ (^2G) $4p$	$^1F°$	3	*41585.24*	
$3d^2\,4s$ (^4F) $4d$	^5G	2	41714.35	43.12
		3	41757.47	61.23
		4	41818.70	84.78
		5	41903.48	115.74
		6	42019.22	
—	$^3H°$	4	*41780.95*	114.20
		5	*41895.15*	100.24
		6	*41995.39*	
$3d^2\,4s$ (^4F) $5p$	$^5D°$	0	*41822.99*	31.02
		1	*41854.01*	52.60
		2	*41906.61*	79.32
		3	*41985.93*	106.59
		4	*42092.52*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\,4s\ (^4F)\ 4d$	^5H	3	41823.19	
				93.86
		4	41917.05	
				100.96
		5	42018.01	
				105.76
		6	42123.77	
				81.82
		7	42205.59	
$3d^2\,4s\ (^4F)\ 4d$	^5D	0	41871.56	
				29.80
		1	41901.36	
				57.15
		2	41958.51	
				94.21
		3	42052.72	
				131.94
		4	42184.66	
$3d^2\,4s\ (^4F)\ 4d$	^3F	2	41871.87	
				116.52
		3	41988.39	
				118.67
		4	42107.06	
$3d^3\ (^2P)\ 4p$	$^3P^\circ$	2	*41928.59*	
				15.36
		1	*41943.95*	
				15.51
		0	*41959.96*	
$3d^3\ (^2D)\ 4p$	$^3D^\circ$	1	*42146.39*	
				60.49
		2	*42206.88*	
				104.43
		3	*42311.31*	
—	$^3D^\circ$	1	*42193.94*	
				75.79
		2	*42269.73*	
				106.98
		3	*42376.71*	
$3d^2\,4s\ (^4F)\ 4d$	$^5P^\circ$	1	*42611.58*	
				112.53
		2	*42724.11*	
				134.79
		3	*42858.90*	
$3d^2\,4s\ (^2S)\ 4p$?	$^1P^\circ$	1	*42927.55*	
$3d^2\,4s\ (^4F)\ 4d$	^5F	1	43034.08	
				46.84
		2	43080.92	
				67.23
		3	43148.15	
				83.84
		4	43231.99	
				98.08
		5	43330.07	
$3d\ 4s^2\ (^2D)\ 4p$	$^3F^\circ$	2	*43467.55*	
				115.59
		3	*43583.14*	
				161.41
		4	*43744.55*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\ (^2H)\ 4p$	$^1G^\circ$	4	*43674.31*	
$3d^3\ (^2P)\ 4p$	$^1D^\circ$	2	*43710.28*	
$3d^3\ (^2D)\ 4p$	$^1D^\circ$	2	*43799.57*	
$3d^3\ (^4F)\ 4d$	^5H	3 4 5 6 7	43843.82 43901.74 43971.55 44051.37 44134.65	57.92 69.81 79.82 83.28
$3d\ 4s^2\ (^2D)\ 4p$	$^3D^\circ$	1 2 3	*43975.62* *44079.39* *44233.15*	103.77 153.76
$3d^3\ (^4F)\ 5p$	$^3G^\circ$	4 5	*44162.44* *44375.57*	213.13
$3d^2\ 4s\ (^2G)\ 4p$	$^1H^\circ$	5	*44163.24*	
$3d^3\ (^4F)\ 4d$	^5D	3 4	44254.39 44381.17	126.78
$3d^2\ 4s\ (^2D)\ 5s$	^1D	2	44581.16	
$3d^3\ (^4F)\ 5p$	$^3F^\circ$	2 3 4	*44825.26* *44923.00* *45041.02*	97.74 118.02
$3d^3\ (^2P)\ 4p$	$^3S^\circ$	1	*44857.89*	
$3d^3\ (^4F)\ 5p$	$^3D^\circ$	1 2 3	*44966.36* *45063.94* *45206.34*	97.58 142.41
$3d\ 4s^2\ (^2D)\ 4p$	$^3P^\circ$	0 1 2	*45040.70* *45090.73* *45178.06*	50.03 87.33
$3d^2\ 4s\ (^2F)\ 4d$	^1H	5	45485.35	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\ (^4F)\ 4d$	^5G	2	—	
		3	45689.89	
				21.39
		4	45711.28	
				45.17
		5	45756.45 ?	
				148.28
		6	45904.73	
$3d^2\ 4s\ \ (^2F)\ 4d$	^3H	4	45721.89	
				110.61
		5	45832.50	
				127.89
		6	45960.39	
$3d^2\ 4s\ \ (^4F)\ 6s$	^5F	1	45764.71	
				48.30
		2	45813.01	
				80.25
		3	45893.26	
				114.36
		4	46007.62	
				150.14
		5	46157.76	
$3d^2\ 4s\ \ (^2F)\ 4d$	^1G	4	46068.04	
$3d^2\ 4s\ \ (^4P)\ 5s$	^3P	2	46244.60	
$3d^3\ (^2F)\ 4p$?	$^1G^\circ$	4	*46257.67*	
$3d^2\ 4s\ \ (^4F)\ 6s$	^3F	4	46530.45	
$3d^2\ 4s\ \ (^2F)\ 4d$	^1F	3	46650.26	
$3d^2\ 4p^2$	^5G	2	46943.91	
				86.37
		3	47030.28	
				109.58
		4	47139.86	
				140.83
		5	47280.69	
				166.15
		6	47446.84	
$3d^2\ 4s\ \ (^2F)\ 4d$	^3F	3	47038.16	
				156.52
		4	47194.68	
$3d^3\ (^4F)\ 6s$	^4F	5	47777.32	
$3d^2\ 4s\ \ (^4F)\ 5d$	^5H	3	47840.62	
				72.99
		4	47913.61	
				80.71
		5	47994.32	
				112.51
		6	48106.83	
				156.00
		7	48262.83	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\,4s\ ({}^4F)\ 5d$	${}^5G$	2	47870.61	
		3	47936.79	66.18
		4	48018.08	81.29
		5	48119.47	101.39
		6	48233.47	114.00
$3d^2\,4p^2$	${}^5F$	1	48058.85	
		2	48107.42	48.57
		3	48208.87	101.45
		4	48328.81	119.94
		5	48462.11	133.30
$3d^2\,4p^2$	${}^5D$	3	48059.82	
		4	48186.11	126.29
$3d^3\ ({}^2F)\ 4p$?	${}^1F^\circ$	3	*48365.09*	
$3d^2\,4s\ ({}^4F)\ 5d$	${}^5F$	2	48519.21	
		3	48588.28	69.07
		4	48672.66	84.38
		5	48771.73	99.07
$3d^4$?	${}^3D$	2	48724.34	
		1	48724.83	
		3	48839.74	
$3d^2\,4s\ ({}^4F)\ 5d$	${}^5D$	0	48802.32	
		1	48859.51	57.19
		2	48915.07	55.56
		3	49024.43	109.36
		4	49036.46	12.03
$3d^3\ ({}^2D)\ 5s$	${}^3D$	2	49571.69	
		3	49619.72	48.03
$3d^2\,4s\ ({}^2D)\ 4d$?	${}^1D$	2	50128.08	
$3d^2\,4s\ ({}^2G)\ 5s$	${}^1G$	4	52125.98	
$3d^3\ ({}^2P)\ 5s$	${}^1P$	1	53663.32	

Ti II $Z = 22$

21 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s\ {}^4F_{1\frac{1}{2}}$

First ionization potential = 13.6 volts

The first spark spectrum of titanium has been classified by Russell. The absolute value of the lowest state is estimated to be 110000 cm.$^{-1}$ with repect to $3d^2\ {}^3F_2$ of Ti III.

References

H. N. Russell, *Astrophys. Journ.* **66,** 1 (1927).
G. R. Harrison, *Journ. Opt. Soc. Am.* **17,** 389 (1928). Intensities.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ ({}^3F)\ 4s$	${}^4F$	$1\frac{1}{2}$	0.00	
				93.94
		$2\frac{1}{2}$	93.94	
				131.53
		$3\frac{1}{2}$	225.47	
				167.75
		$4\frac{1}{2}$	393.22	
$3d^3$	${}^4F$	$1\frac{1}{2}$	907.96	
				75.84
		$2\frac{1}{2}$	983.80	
				103.41
		$3\frac{1}{2}$	1087.21	
				128.37
		$4\frac{1}{2}$	1215.58	
$3d^2\ ({}^3F)\ 4s$	${}^2F$	$2\frac{1}{2}$	4628.61	
				268.99
		$3\frac{1}{2}$	4897.60	
$3d^2\ ({}^1D)\ 4s$	${}^2D$	$1\frac{1}{2}$	8710.47	
				33.80
		$2\frac{1}{2}$	8744.27	
$3d^3$	${}^2G$	$3\frac{1}{2}$	8997.69	
				120.46
		$4\frac{1}{2}$	9118.15	
$3d^3$	${}^4P$	$\frac{1}{2}$	9363.71	
				32.05
		$1\frac{1}{2}$	9395.76	
				122.29
		$2\frac{1}{2}$	9518.05	
$3d^3$	${}^2P$	$\frac{1}{2}$	9850.90	
				125.02
		$1\frac{1}{2}$	9975.92	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3P)\ 4s$	^4P	$\frac{1}{2}$	9872.87	
		$1\frac{1}{2}$	9930.74	57.87
		$2\frac{1}{2}$	10024.74	94.00
$3d^3$	^2H	$4\frac{1}{2}$	12676.99	
		$5\frac{1}{2}$	12774.81	97.82
$3d^3$	^2D	$1\frac{1}{2}$	12628.77	
		$2\frac{1}{2}$	12758.15	129.38
$3d^2\ (^1G)\ 4s$	^2G	$4\frac{1}{2}$	15257.53	
		$3\frac{1}{2}$	15265.60	−8.07
$3d^2\ (^3P)\ 4s$	^2P	$\frac{1}{2}$	16515.79	
		$1\frac{1}{2}$	16625.25	109.46
$3d^3$	^2F	$3\frac{1}{2}$	20891.88	
		$2\frac{1}{2}$	20951.77	−59.89
$4d^2\ (^1S)\ 4s$	^2S	$\frac{1}{2}$	21338.00	
$3d\ 4s^2$	^2D	$1\frac{1}{2}$	24961.34	
		$2\frac{1}{2}$	25193.04	231.70
$3d^2\ (^3F)\ 4p$	$^4G^\circ$	$2\frac{1}{2}$	*29544.37*	
		$3\frac{1}{2}$	*29734.45*	190.08
		$4\frac{1}{2}$	*29968.08*	233.63
		$5\frac{1}{2}$	*30240.68*	272.60
$3d^2\ (^3F)\ 4p$	$^4F^\circ$	$1\frac{1}{2}$	*30836.52*	
		$2\frac{1}{2}$	*30958.70*	122.18
		$3\frac{1}{2}$	*31113.92*	154.91
		$4\frac{1}{2}$	*31300.92*	187.31
$3d^2\ (^3F)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	*31207.44*	
		$3\frac{1}{2}$	*31490.82*	283.38
$3d^2\ (^3F)\ 4p$	$^2D^\circ$	$1\frac{1}{2}$	*31756.50*	
		$2\frac{1}{2}$	*32025.50*	269.00
$3d^2\ (^3F)\ 4p$	$^2G^\circ$	$3\frac{1}{2}$	*34543.36*	
		$4\frac{1}{2}$	*34748.50*	205.14

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3F)\ 4p$	$^4D^\circ$	$\frac{1}{2}$	32532.38	
		$1\frac{1}{2}$	32602.51	70.13
		$2\frac{1}{2}$	32697.94	95.43
		$3\frac{1}{2}$	32767.02	69.08
$3d^2\ (^3P)\ 4p$	$^2S^\circ$	$\frac{1}{2}$	37430.55	
$3d^2\ (^1D)\ 4p$	$^2P^\circ$	$1\frac{1}{2}$	39602.90	
		$\frac{1}{2}$	39674.64	−71.74
$3d^2\ (^3P)\ 4p$	$^4S^\circ$	$\frac{1}{2}$	40027.28	
$3d^2\ (^1D)\ 4p$	$^2D^\circ$	$1\frac{1}{2}$	39233.44	
		$2\frac{1}{2}$	39476.87	243.43
$3d^2\ (^1D)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	39926.83	
		$3\frac{1}{2}$	40074.71	147.88
$3d^2\ (^3P)\ 4p$	$^4D^\circ$	$\frac{1}{2}$	40330.25	
		$1\frac{1}{2}$	40425.80	95.55
		$2\frac{1}{2}$	40581.80	156.00
		$3\frac{1}{2}$	40798.37	216.57
$3d^2\ (^3P)\ 4p$	$^4P^\circ$	$\frac{1}{2}$	41996.74	
		$1\frac{1}{2}$	42068.85	72.01
		$2\frac{1}{2}$	42208.84	139.99
$3d^2\ (^1G)\ 4p$	$^2G^\circ$	$3\frac{1}{2}$	43740.77	
		$4\frac{1}{2}$	43780.99	40.22
$3d^2\ (^3P)\ 4p$	$^2D^\circ$	$2\frac{1}{2}$	44902.42	
		$1\frac{1}{2}$	44914.80	−12.38
$3d^2\ (^3P)\ 4p$	$^2P^\circ$	$\frac{1}{2}$	45472.89	
		$1\frac{1}{2}$	45548.90	76.01
$3d^2\ (^1G)\ 4p$	$^2H^\circ$	$4\frac{1}{2}$	45673.75	
		$5\frac{1}{2}$	45908.56	234.81
$3d^2\ (^1G)\ 4p$	$^2F^\circ$	$3\frac{1}{2}$	47466.80	
		$2\frac{1}{2}$	47625.17	−158.37
$3d\ 4s\ (^3D)\ 4p$	$^4D^\circ$	$\frac{1}{2}$	52329.78	
		$1\frac{1}{2}$	52458.98	129.20
		$2\frac{1}{2}$	52471.48	12.50
		$3\frac{1}{2}$	52631.07	159.59

TITANIUM II

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4s\ (^3D)\ 4p$	$^2P^\circ$	$\frac{1}{2}$	*53121.48*	
		$1\frac{1}{2}$	*53128.17*	6.69
$3d\ 4s\ (^3D)\ 4p$	$^2D^\circ$	$2\frac{1}{2}$	*53554.90*	
		$1\frac{1}{2}$	*53596.70*	−41.80
$3d\ 4s\ (^3D)\ 4p$	$^4P^\circ$	$\frac{1}{2}$	*56223.13*	
		$1\frac{1}{2}$	*56249.11*	25.98
		$2\frac{1}{2}$	*56325.94*	76.83
$3d\ 4s\ (^3D)\ 4p$	$^2F^\circ$	$2\frac{1}{2}$	*59321.79*	
		$3\frac{1}{2}$	*59467.81*	146.02
$3d^2\ (^3F)\ 5s$	^4F	$1\frac{1}{2}$	62180.02	
		$2\frac{1}{2}$	62271.25	91.23
		$3\frac{1}{2}$	62409.58	138.33
		$4\frac{1}{2}$	62594.27	184.69
$3d^2\ (^3F)\ 5s$	^2F	$2\frac{1}{2}$	63168.23	
		$3\frac{1}{2}$	63444.76	276.53
$3d^2\ (^3F)\ 4d$	^4G	$2\frac{1}{2}$	64884.65	
		$3\frac{1}{2}$	64977.57	92.92
		$4\frac{1}{2}$	65094.29	116.72
		$5\frac{1}{2}$	65241.60	147.31
$3d^2\ (^3F)\ 4d$	^2F	$2\frac{1}{2}$	65312.71	
		$3\frac{1}{2}$	65458.65	145.94
$3d^2\ (^3F)\ 4d$	^4H	$3\frac{1}{2}$	65184.72	
		$4\frac{1}{2}$	65307.45	122.73
		$5\frac{1}{2}$	65445.85	138.40
		$6\frac{1}{2}$	65589.10	143.25
$3d^2\ (^3F)\ 4d$	^4D	$\frac{1}{2}$	66767.43 ?	
		$1\frac{1}{2}$	66816.49	49.06
		$2\frac{1}{2}$	66937.70	121.21
		$3\frac{1}{2}$	66996.67	58.97
$3d^2\ (^3F)\ 4d$	^2G	$3\frac{1}{2}$	67604.20	
		$4\frac{1}{2}$	67820.87	216.67
$3d^2\ (^3F)\ 4d$	^2H	$4\frac{1}{2}$	68328.95	
		$5\frac{1}{2}$	68582.34	253.39

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\ (^3F)\ 4d$	^4F	$1\frac{1}{2}$	68767.66	
				77.48
		$2\frac{1}{2}$	68845.14	
				105.25
		$3\frac{1}{2}$	68950.39	
				130.96
		$4\frac{1}{2}$	69081.35	
$3d\ 4s\ (^1D)\ 4p$	$^2D°$	$1\frac{1}{2}$	*69327.32*	
				294.83
		$2\frac{1}{2}$	*69622.15*	
$3d\ 4s\ (^1D)\ 4p$	$^2F°$	$2\frac{1}{2}$	*70606.35*	
				286.65
		$3\frac{1}{2}$	*70893.00*	

Ti III $Z = 22$

20 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^2\;{}^3F_2$

Ionization potential = 27.6 volts

The classification is given by Russell and Lang. The lowest configuration is $3d^2$, whereas it was $3d\,4s$ in Sc II, and $4s^2$ in Ca I. The absolute value of the lowest state is about 340000 cm.$^{-1}$.

Reference

H. N. Russell and R. J. Lang, *Astrophys. Journ.* **66**, 13 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2$	^3F	2	0.0	
				183.7
		3	183.7	
				238.2
		4	421.9	
$3d^2$	^1D	2	8472.6	
$3d^2$	^3P	0	10536.4	
				67.1
		1	10603.5	
				117.6
		2	10721.1	
$3d^2$	^1S	0	14052.7 ?	
$3d^2$	^1G	4	14398.5	
$3d\;4s$	^3D	1	38063.50	
				134.48
		2	38197.98	
				227.21
		3	38425.19	
$3d\;4s$	^1D	2	41703.65	
$3d\;4p$	$^1D^\circ$	2	*75197.43*	
$3d\;4p$	$^3D^\circ$	1	*76999.70*	
				166.95
		2	*77166.65*	
				257.55
		3	*77424.20*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\ 4p$	$^3F^\circ$	2	*77421.48*	
				324.70
		3	*77746.18*	
				412.53
		4	*78158.71*	
$3d\ 4p$	$^3P^\circ$	1	*80938.02*	
		0	*80943.95*	
		2	*81023.60*	
$3d\ 4p$	$^1F^\circ$	3	*83116.58*	
$3d\ 4p$	$^1P^\circ$	1	*83795.70*	
$3d\ 4d$	^3G	3	129096.3	
				159.7
		4	129256.0	
				216.6
		5	129472.6	
$3d\ 4d$	^3D	1		
		2	129873.9	
				145.6
		3	130019.5	
$3d\ 4d$	^3S	2	132854.6	
$3d\ 4d$	^3F	2	133067.2	
				142.5
		3	133209.7	
				164.0
		4	133373.7	
$3d\ 4d$	^3P	0	135543.8	
				58.6
		1	135602.4	
				121.7
		2	135724.1	
$4s\ 4p$	$^3P^\circ$	0	*137262*	
				228
		1	*137490*	
				481
		2	*137971*	

Ti IV $\quad Z = 22$

19 electrons $\quad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d\;{}^2D_{1\frac{1}{2}}$

Ionization potential = 43.06 volts

The classification has been taken from the work of Russell and Lang.

Reference

H. N. Russell and R. J. Lang, *Astrophys. Journ.* **66**, 13 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	348817.8 348433.5	384.3
$4s$	${}^2S$	$\frac{1}{2}$	268439.2	
$4p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*220905.3* *220086.9*	818.4
$4d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	152023.0 151937.3	85.7
$5s$	${}^2S$	$\frac{1}{2}$	136422.0	
$5p$	${}^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*118220.2* *117904.4*	315.8
$4f$	${}^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*112692.5* *112685.3*	7.2
$5d$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	89990.6 89951.1	39.5
$6s$	${}^2S$	$\frac{1}{2}$	82982.0	
$5g$	${}^2G$	$3\frac{1}{2},\ 4\frac{1}{2}$	70316.7	
$6h$	${}^2H^\circ$	$4\frac{1}{2},\ 5\frac{1}{2}$	*48805.3*	
$7h$	${}^2H^\circ$	$4\frac{1}{2},\ 5\frac{1}{2}$	*35844.3*	

81 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ 6p\ {}^2P^\circ_{\frac{1}{2}}$

Ionization potential = 6.07 volts

The classification is given in Paschen-Götze and in Fowler. The first table contains only the lowest terms. The hyperfine structure has been investigated recently and has shown that the nuclear moment is $I = \frac{1}{2}$. The hyperfine structure separations are

$6p\ {}^2P_{\frac{1}{2}}$ .... 0.710 cm.$^{-1}$
$6p\ {}^2P_{1\frac{1}{2}}$ .... very small
$6s\ {}^2S_{\frac{1}{2}}$ .... 0.402 cm.$^{-1}$

References

H. Schüler and H. Brück, *Zeits. f. Physik* **56**, 291 (1929).
E. Back and J. Wulff, *Zeits. f. Physik* **66**, 31 (1930). Zeeman effect of hyperfine structure.
J. Wulff, *Zeits. f. Physik* *69*, 70, (1931).
H. Schüler, *Naturwiss.* *19*, 320 (1931). Isotope effect.

Configuration	Symbol	J	Term value	$\Delta\nu$
$6s^2\ 6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*49264.2* *41471.5*	7792.7
$7s$	^2S	$\frac{1}{2}$	22786.7	
$7p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*15104.6* *14103.4*	1001.2
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	13146.2 10064.3	81.9
$8s$	^2S	$\frac{1}{2}$	10518.3	
$8p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*7895.9* *7523.2*	372.7
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	7252.8 7215.2	37.6
$5f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*6945.8*	

SERIES

$6s^2\ ms$	
m	$^2S_{\frac{1}{2}}$
7	22786.7
8	10518.3
9	6098.2
10	3968.2
11	2808.9
12	2085.0
13	1610.2
14	1282.3
15	1040.0
16	865.3
17	730.5
18	626.0
19	536.5

$6s^2\ mp$		
m	$^2P_{\frac{1}{2}}^\circ$	$^2P_{1\frac{1}{2}}^\circ$
6	*49624.2*	*41471.5*
7	*15104.6*	*14103.4*
8	*7895.9*	*7523.2*
9	*4883.3*	*4701.7*
10	*3324.9*	*3220.6*
11	*2410.4*	*2347.1*
12	*1821.6*	*1786.8*
13	*1416.5*	Unresolved
14	*1134.6*	
15	*933.0*	
16	*804.7*	

$6s^2\ md$		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
6	13146.2	13064.3
7	7252.8	7215.2
8	4591.6	4571.5
9	3165.8	3153.9
10	2314.7	2306.4
11	1760.1	Unresolved
12	1385.9	
13	1120.3	
14	923.5	
15	774.6	
16	659.0	
17	565.7	
18	491.9	

$6s^2\ mf$	
m	$^2F_{2\frac{1}{2},3\frac{1}{2}}^\circ$
5	*6945.8*
6	*4440.7*
7	—
8	*2244.9* ?

Tl II $\quad Z = 81$

80 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ 6s^2\ {}^1S_0$

Ionization potential = 20.3 volts

This classification has been given according to Smith. McLennan, McLay, and Crawford discovered rather large hyperfine structures, confirming for the nuclear moment that $I = \frac{1}{2}$. The level separations, which have not yet been measured with accuracy, are given in the last column. The absolute value of $6s^2\ {}^1S_0$ is about 164600 cm.$^{-1}$.

References

S. Smith, *Phys. Rev.* **35**, 235 (1930).

J. C. McLennan, A. B. McLay, and M. F. Crawford, *Proc. Roy. Soc.* **125**, 570 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$	Hyperfine structure
$6s^2$	^1S	0	0		
$6s\,6p$	$^3P^\circ$	0	*49452*		
		1	*52393*	2941	−0.05
		2	*61726*	9333	3.5
	$^1P^\circ$	1	*75662*		
$6s\,7s$	^3S	1	105206		5.0
	^1S	0	107997		
$6s\,6d$	^1D	2	115164		2.0
	^3D	1	116112		−1.5
		2	116436	324	1.0
		3	116829	393	
$6p^2$	^3P	0	117409		
		1	125340	7931	
		2	—		

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$	Hyperfine structure
$6s\ 7p$	$^3P^\circ$	0	*119361*		
		1	*119577*	216	4.0
		2	*122031*	2454	3.5
—	1°	1	*122381*		−0.5
$6s\ 7p$	$^1P^\circ$	1	*126206*		−0.5
$6p^2$	^1D	2	128819		
$6s\ 5f$	$^3F^\circ$	3	*136119*		1.0
		2	*136222*		−2.0
		4	*136236*		
$5f$	$^1F^\circ$	3	*136269*		
$6s\ 7d$	^1D	2	136893		0.5
$7d$	^3D	1	137928		−2.5
		2	138055	127	0.5
		3	138204	149	4.0
—	2°	3	*142785*		
$6s\ 9s$	^3S	1	145415		4.5
$6s\ 8d$	^1D	2	146418		−5.0
$6s\ 6f$	$^3F^\circ$	4	*146504*		
		2	*146529*		−2.0
		3	*146539*		−2.5
$6s\ 8d$	^3D	1	147603		−2.0
		2	147654	51	1.0
		3	147749	95	
$6s\ 10s$	^3S	1	151748		
$6s\ 7f$	$^3F^\circ$	2, 3, 4,	*152116*		

79 electrons Ionization potential = 29.7 volts.

$1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,4f^{14}\,5s^2\,5p^6\,5d^{10}\,6s\ {}^2S_{\frac{1}{2}}$

The levels based upon $5d^{10}$ have been taken from the paper by McLennan, McLay, and Crawford; those involving $5d^9\,6s$ are from Pattabiramayya and A. S. Rao. The latter are given in a separate table because they are somewhat uncertain, especially as far as their position with respect to the other levels is concerned. The absolute value of $6s\ {}^2S_{\frac{1}{2}}$ is estimated 240600 cm.$^{-1}$ with respect to $5d^{10}\ {}^1S$ of Tl IV.

References

J. C. McLennan, A. B. McLay and M. F. Crawford, *Proc. Roy. Soc.* **A125,** 50 (1929).

J. D. McLennan and E. J. Allin, *Proc. Roy. Soc.* **A129,** 43 (1930). Hyperfine structure.

G. Arvidsson, *Nature* **126,** 565 (1930).

P. Pattabiramayya and A. S. Rao, *Indian Journ. Phys.* **5,** 407 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d^{10}\,6s$	^2S	$\frac{1}{2}$	0	
$6p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*64157* *78970*	14813
$7s$	^2S	$\frac{1}{2}$	139209	
$6d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	145355 146669	1314
$7p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*157852* *163534*	5682
$5f$	$^2F^\circ$	$3\frac{1}{2}$ $2\frac{1}{2}$	*175593* *176955*	−1362
$8s$	^2S	$\frac{1}{2}$	183187	
$7d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	186356 186948	592
$5g$	^2G	$3\frac{1}{2}, 4\frac{1}{2}$	201011	

THALLIUM III

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$5d^9\,6s^2$	^2D	$2\frac{1}{2}$	63084	-18618
		$1\frac{1}{2}$	81702	
$5d^9\,6s\,6p$	$^4F^\circ$	$3\frac{1}{2}$	*111467*	-12682
		$2\frac{1}{2}$	*124149*	-16888
		$1\frac{1}{2}$	*141037*	
$5d^9\,6s\,6p$	$^4D^\circ$	$3\frac{1}{2}$	*123857*	-17574
		$2\frac{1}{2}$	*141431*	-7607
		$1\frac{1}{2}$	*149038*	-4308
		$\frac{1}{2}$	*153346*	
$5d^9\,6s\,6p$	$^4P^\circ$	$2\frac{1}{2}$	*142915*	-12890
		$1\frac{1}{2}$	*155805*	5042
		$\frac{1}{2}$	*150763*	
$5d^9\,6s\,6d$	^4F	$4\frac{1}{2}$	143881	-8107
		$3\frac{1}{2}$	151988	-4578
		$2\frac{1}{2}$	156566	-2794
		$1\frac{1}{2}$	159360	
$5d^9\,6s\,6d$	^4D	$3\frac{1}{2}$	163246	-9415
		$2\frac{1}{2}$	172661	-4580
		$1\frac{1}{2}$	177241	-3577
		$\frac{1}{2}$	180818	
$5d^9\,6s\,6d$	^4P	$2\frac{1}{2}$	174540	-5074
		$1\frac{1}{2}$	179614	-1056
		$\frac{1}{2}$	180670	

Hyperfine Structure Separations

Nuclear moment $I = \frac{1}{2}$

$6s$	$^2S_{\frac{1}{2}}$	$\Delta\nu \sim 6.4$ cm.$^{-1}$
$6p$	$^2P_{\frac{1}{2}}^\circ$	1.21
$6d$	$^2D_{1\frac{1}{2}}$	Very small
$7s$	$^2S_{\frac{1}{2}}$	1.37
$7p$	$^2P_{\frac{1}{2}}^\circ$	0.375
$7p$	$^2P_{1\frac{1}{2}}^\circ$	0.437
$8s$	$^2S_{\frac{1}{2}}$	0.606
$5f$	$^2F_{3\frac{1}{2}}^\circ$	0.145
	$^2F_{2\frac{1}{2}}^\circ$	0.220

78 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^{10}\ {}^1S_0$

These terms are taken from a paper by Mack. Arvidsson has observed some large hyperfine structures.

References

J. E. Mack, *Phys. Rev.* **34**, 17 (1929).
K. R. Rao, *Proc. London Phys. Soc.* **41**, 361 (1929).
G. Arvidsson, *Nature* **126**, 565 (1930).

Configuration	Symbol	J	Term value	
$5d^9\ ({}^2D_{2\frac{1}{2}})\ 6s$	1	3	0	${}^3D$
	2	2	3588	${}^3D$
$({}^2D_{1\frac{1}{2}})\ 6s$	3	1	18865	${}^3D$
	4	2	21681	${}^1D$
$5d\ ({}^2D)\ 6p$	1°	2	*72582*	
	2°	3	*74783*	
	3°	4	*92617*	
	4°	2	*95285*	
	5°	3	*97217*	
	6°	1	*100233*	

23 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2\ {}^4F_{1\frac{1}{2}}$

Ionization potential = 6.76 volts

These term values of the arc spectrum of vanadium are from the unpublished work of Meggers. The configurations $3d^3\,4s\,4p$ and $3d^4\,4p$ overlap so completely that the assignment of electron configurations for the higher terms is very doubtful.

References

K. Bechert and L. A. Sommer, *Zeits. f. Physik* **31,** 145 (1925).
O. Laporte, *Physik. Zeits.* **24,** 510 (1923); *Naturwiss.* **11,** 779 (1923).
W. F. Meggers, *Journ. Wash. Acad. Sci.* **13,** 317 (1923); **14,** 151 (1924).
W. F. Meggers, C. C. Kiess, and F. M. Walters, *Journ. Opt. Soc. Am.* **9,** 355 (1924).
H. N. Russell, *Astrophys. Journ.* **66,** 233 (1927).
W. F. Meggers, unpublished material.

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\,4s^2$	^4F	$1\frac{1}{2}$	0.00	
				137.38
		$2\frac{1}{2}$	137.38	
				186.04
		$3\frac{1}{2}$	323.42	
				229.60
		$4\frac{1}{2}$	553.02	
$3d^4\,(^5D)\,4s$	^6D	$\frac{1}{2}$	2112.32	
				40.88
		$1\frac{1}{2}$	2153.20	
				66.93
		$2\frac{1}{2}$	2220.13	
				91.24
		$3\frac{1}{2}$	2311.37	
				113.52
		$4\frac{1}{2}$	2424.89	
$3d^4\,(^5D)\,4s$	^4D	$\frac{1}{2}$	8412.94	
				63.26
		$1\frac{1}{2}$	8476.20	
				102.32
		$2\frac{1}{2}$	8578.52	
				137.20
		$3\frac{1}{2}$	8715.72	
$3d^3\,4s^2$	^4P	$\frac{1}{2}$	9544.54	
				92.42
		$1\frac{1}{2}$	9636.96	
				187.62
		$2\frac{1}{2}$	9824.58	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^4\,(^3H)\,4s$	^4H	$3\frac{1}{2}$	14910.4	
		$4\frac{1}{2}$	14949.4	39.0
		$5\frac{1}{2}$	15000.9	51.5
		$6\frac{1}{2}$	15063.0	62.1
$3d^4\,(^3P)\,4s$	^4P	$\frac{1}{2}$	15078.3	
		$1\frac{1}{2}$	15270.5	192.2
		$2\frac{1}{2}$	15571.9	301.4
$3d^4\,(^3F)\,4s$	^4F	$1\frac{1}{2}$	15664.5	
		$2\frac{1}{2}$	15688.6	24.1
		$3\frac{1}{2}$	15724.0	35.4
		$4\frac{1}{2}$	15770.3	46.3
$3d^3\,4s\,(^5F)\,4p$	$^6G^\circ$	$1\frac{1}{2}$	*16361.35*	
		$2\frac{1}{2}$	*16449.77*	88.42
		$3\frac{1}{2}$	*16572.51*	122.74
		$4\frac{1}{2}$	*16728.72*	156.21
		$5\frac{1}{2}$	*16917.12*	188.40
		$6\frac{1}{2}$	*17136.38*	219.26
$3d^4\,(^3G)\,4s$	^4G	$2\frac{1}{2}$	17054.9	
		$3\frac{1}{2}$	17117.1	63.2
		$4\frac{1}{2}$	17181.8	64.7
		$5\frac{1}{2}$	17242.0	60.2
$3d^3\,4s\,(^5F)\,4p$	$^6D^\circ$	$\frac{1}{2}$	*18085.82*	
		$1\frac{1}{2}$	*18126.17*	40.35
		$2\frac{1}{2}$	*18198.05*	71.88
		$3\frac{1}{2}$	*18302.27*	104.22
		$4\frac{1}{2}$	*18438.07*	135.80
$3d^3\,4s\,(^5F)\,4p$	$^6F^\circ$	$\frac{1}{2}$	*18120.08*	
		$1\frac{1}{2}$	*18174.06*	53.98
		$2\frac{1}{2}$	*18258.87*	84.81
		$3\frac{1}{2}$	*18372.46*	113.59
		$4\frac{1}{2}$	*18513.49*	141.03
		$5\frac{1}{2}$	*18680.5*	167.0
$3d^3\,4s\,(^5F)\,4p$	$^4D^\circ$	$\frac{1}{2}$	*20606.46*	
		$1\frac{1}{2}$	*20687.80*	81.34
		$2\frac{1}{2}$	*20828.49*	140.69
		$3\frac{1}{2}$	*21032.44*	203.95

VANADIUM I

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\,4s\,(^5F)\,4p$	$^4G^\circ$	$2\frac{1}{2}$	21841.40	
				122.00
		$3\frac{1}{2}$	21963.40	
				157.69
		$4\frac{1}{2}$	22121.09	
				192.83
		$5\frac{1}{2}$	22313.92	
$3d^3\,4s\,(^5F)\,4p$	$^4F^\circ$	$1\frac{1}{2}$	23088.04	
				122.48
		$2\frac{1}{2}$	23210.52	
				142.54
		$3\frac{1}{2}$	23353.06	
				166.78
		$4\frac{1}{2}$	23519.84	
—	$^2D^\circ$	$1\frac{1}{2}$	23608.7	
				326.5
		$2\frac{1}{2}$	23935.2	
$3d^4\,(^5D)\,4p$	$^6P^\circ$	$1\frac{1}{2}$	24648.10	
				79.74
		$2\frac{1}{2}$	24727.84	
				110.73
		$3\frac{1}{2}$	24838.57	
$3d^4\,(^5D)\,4p$	$^4P^\circ$	$\frac{1}{2}$	24770.58	
				144.49
		$1\frac{1}{2}$	24915.07	
				215.85
		$2\frac{1}{2}$	25130.92	
$3d^4\,(^5D)\,4p$	$^6F^\circ$	$\frac{1}{2}$	24789.30	
				40.88
		$1\frac{1}{2}$	24830.18	
				68.57
		$2\frac{1}{2}$	24898.75	
				94.10
		$3\frac{1}{2}$	24992.85	
				118.59
		$4\frac{1}{2}$	25111.44	
				141.98
		$5\frac{1}{2}$	25253.42	
$3d^4\,(^5D)\,4p$	$^4F^\circ$	$1\frac{1}{2}$	25930.50	
				73.72
		$2\frac{1}{2}$	26004.22	
				117.85
		$3\frac{1}{2}$	26122.07	
				49.90
		$4\frac{1}{2}$	26171.97	
$3d^4\,(^5D)\,4p$	$^4D^\circ$	$\frac{1}{2}$	26182.63	
				66.81
		$1\frac{1}{2}$	26249.44	
				103.18
		$2\frac{1}{2}$	26352.62	
				127.68
		$3\frac{1}{2}$	26480.30	
$3d^4\,(^5D)\,4p$	$^6D^\circ$	$\frac{1}{2}$	26397.22	
				40.42
		$1\frac{1}{2}$	26437.64	
				68.25
		$2\frac{1}{2}$	26505.89	
				98.88
		$3\frac{1}{2}$	26604.77	
				133.50
		$4\frac{1}{2}$	26738.27	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\,4s\,(^5P)\,4p$	$^6D°$	½	*28313.63*	
		1½	*28368.73*	55.10
		2½	*28462.17*	93.44
		3½	*28595.57*	133.40
		4½	*28768.10*	172.53
$3d^3\,4s\,(^5P)\,4p$	$^6P°$	1½	*29202.76*	
		2½	*29296.43*	93.67
		3½	*29418.15*	121.72
—	$^4P°$	½	*30021.64*	
		1½	*30094.57*	72.93
		2½	*30120.80*	26.23
$3d^4\,(^3G)\,4p$	$^4H°$	3½	*30593.6*	
		4½	*30620.7*	27.1
		5½	*30716.7*	96.0
		6½	*30784.8*	68.1
$3d^4\,(^3G)\,4p$	$^4G°$	2½	*30635.60*	
		3½	*30694.36*	58.76
		4½	*30771.74*	77.38
		5½	*30864.32*	92.58
$3d^4\,(^3G)\,4p$	$^4F°$	1½	*31200.1*	
		2½	*31229.0*	28.9
		3½	*31267.6*	38.6
		4½	*31317.4*	49.8
—	$^4G°$	2½	*31398.04*	
		3½	*31541.19*	143.15
		4½	*31721.64*	180.45
		5½	*31937.02*	215.38
—	$^2D°$?	1½	*32738.27*	
		2½	*32891.10*	152.83
$3d^4\,4p$	$^4F°$	1½	*32767.91*	
		2½	*32846.79*	78.88
		3½	*32988.85*	142.06
		4½	*33155.35*	166.50
—	$^4D°$	½	*33066.74*	
		1½	—	
		2½	*34065.72*	
		3½	*34127.88*	62.16

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$^2D^\circ$	$1\frac{1}{2}$	*33976.00*	
—	1°	$2\frac{1}{2}$?	*34016.3*	
	2°	$1\frac{1}{2}$	*34030.0*	
	3°	$3\frac{1}{2}$	*34375.0*	
—	$^2D^\circ$?	$1\frac{1}{2}$	*34428.85*	
				57.95
		$2\frac{1}{2}$	*34486.80*	
—	$^4D^\circ$	$\frac{1}{2}$	*34477.44*	
				59.84
		$1\frac{1}{2}$	*34537.28*	
				82.24
		$2\frac{1}{2}$	*34619.52*	
				127.52
		$3\frac{1}{2}$	*34747.04*	
—	$^4D^\circ$	$\frac{1}{2}$	*35012.96*	
				79.20
		$1\frac{1}{2}$	*35092.16*	
				133.04
		$2\frac{1}{2}$	*35225.20*	
				153.95
		$3\frac{1}{2}$	*35379.15*	
—	4°	$2\frac{1}{2}$	*35698.5*	
	5°	$3\frac{1}{2}$	*35769.2*	
	6°	$1\frac{1}{2}$	*35809.8*	
$3d^4\ (^3H)\ 4p$	$^4I^\circ$	$4\frac{1}{2}$	*37180.9*	
				135.0
		$5\frac{1}{2}$	*37315.9*	
				140.7
		$6\frac{1}{2}$	*37456.6*	
				150.2
		$7\frac{1}{2}$	*37606.8* ?	
$3d^3\ 4s\ (^5F)\ 5s$	^6F	$\frac{1}{2}$	37374.98	
				48.06
		$1\frac{1}{2}$	37423.04	
				80.05
		$2\frac{1}{2}$	37503.09	
				111.84
		$3\frac{1}{2}$	37614.93	
				143.05
		$4\frac{1}{2}$	37757.98	
				173.30
		$5\frac{1}{2}$	37931.28	
—	$^4D^\circ$	$\frac{1}{2}$	*37757.29*	
				77.70
		$1\frac{1}{2}$	*37834.99*	
				124.64
		$2\frac{1}{2}$	*37959.63*	
				155.88
		$3\frac{1}{2}$	*38115.51*	
$3d^4\ (^3H)\ 4p$	$^4H^\circ$	$3\frac{1}{2}$	*38245.8*	
				78.1
		$4\frac{1}{2}$	*38323.9*	
				81.1
		$5\frac{1}{2}$	*38405.0*	
				78.0
		$6\frac{1}{2}$	*38483.0*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
—	$^4P^\circ$	$\frac{1}{2}$	*39237.15*	
		$1\frac{1}{2}$	*39248.83*	11.68
		$2\frac{1}{2}$	*39422.65*	173.82
$3d^3\,4s\,(^5F)\,5s$	^4F	$1\frac{1}{2}$	39266.33	
		$2\frac{1}{2}$	39300.31	33.98
		$3\frac{1}{2}$	39341.25	40.94
		$4\frac{1}{2}$	39390.64	49.39
—	$^4H^\circ$	$3\frac{1}{2}$	*40315.1*	
		$4\frac{1}{2}$	*40378.8*	63.7
		$5\frac{1}{2}$	*40452.5*	73.7
		$6\frac{1}{2}$	*40535.7*	83.2
—	$^4F^\circ$	$1\frac{1}{2}$	*41389.32*	
		$2\frac{1}{2}$	*41429.04*	39.72
		$3\frac{1}{2}$	*41492.04*	63.00
		$4\frac{1}{2}$	*41599.15*	107.11
$3d^4\,(^3H)\,4p$	$^4G^\circ$	$2\frac{1}{2}$	*41654.5*	
		$3\frac{1}{2}$	*41758.5*	104.0
		$4\frac{1}{2}$	*41860.3*	101.8
		$5\frac{1}{2}$	*41918.2*	57.9
—	$^4F^\circ$	$1\frac{1}{2}$	*42981.0*	
		$2\frac{1}{2}$	*43051.1*	70.1
		$3\frac{1}{2}$	*43146.2*	95.1
		$4\frac{1}{2}$	*43265.7*	119.5
—	$^4D^\circ$	$\frac{1}{2}$	*43249.6*	
		$1\frac{1}{2}$	*43309.1*	59.5
		$2\frac{1}{2}$	*43411.0*	101.9
		$3\frac{1}{2}$	*43555.2*	144.2
—	$^4G^\circ$	$2\frac{1}{2}$	*46053.6*	
		$3\frac{1}{2}$	*46140.0*	86.4
		$4\frac{1}{2}$	*46244.7*	104.7
		$5\frac{1}{2}$	*46364.1*	119.4
—	$^4F^\circ$	$1\frac{1}{2}$	*47802.8*	
		$2\frac{1}{2}$	*47916.8*	114.0
		$3\frac{1}{2}$	*48141.2*	224.4
		$4\frac{1}{2}$	*48329.0*	187.8

V II $\quad Z = 23$

22 electrons $\quad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ {}^5D_0$

First ionization potential = 14.1 volts

The classification has been given for the greater part by Meggers. The assignments given here are largely from Russell. The absolute value of the lowest state is 114600 cm.$^{-1}$ with respect to $3d^3\ {}^4F$ of V III.

References

W. F. MEGGERS, *Zeits. f. Physik.* **33**, 509 (1925); **39**, 114 (1925).
H. N. RUSSELL, *Astrophys. Journ.* **66**, 194 (1927); **66**, 347 (1927).
H. E. WHITE, *Phys. Rev.* **33**, 914 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^4$	^5D	0	0.00	
		1	36.06	36.06
		2	106.70	70.64
		3	208.80	102.10
		4	339.26	130.36
$3d^3\ (^4F)\ 4s$	^5F	1	2604.70	
		2	2686.87	82.17
		3	2808.61	121.74
		4	2986.07	159.46
		5	3162.57	194.50
$3d^3\ (^4F)\ 4s$	^3F	2	8639.82	
		3	8841.52	201.70
		4	9097.34	255.82
$3d^4$	^3P	0	11295.00	
		1	11514.40	219.40
		2	11907.90	393.50
$3d^4$	^3F	2	13490.33	
		3	13542.15	51.82
		4	13608.39	66.24

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\ (^4P)\ 4s$	^5P	1	13511.20	
				83.00
		2	13594.20	
				147.04
		3	13741.23	
$3d^3\ (^2G)\ 4s$	^3G	3	14461.26	
				94.26
		4	14555.52	
				99.56
		5	14655.08	
$3d^4$	^3G	3	16340.56	
				80.40
		4	16420.96	
				111.33
		5	16532.29	
$3d^3\ (^2H)\ 4s$	^3H	4	20241.75	
				37.95
		5	20279.70	
				83.10
		6	20362.80	
$3d^3\ (^4F)\ 4p$	$^5G^\circ$	2	*34592.53*	
				152.98
		3	*34745.51*	
				200.82
		4	*34946.33*	
				246.55
		5	*35192.88*	
				290.47
		6	*35483.35*	
$3d^3\ (^4F)\ 4p$?	$^3D^\circ$	1	*36488.94*	
				184.22
		2	*36673.16*	
				245.68
		3	*36918.84*	
$3d^3\ (^4P)\ 4p$?	$^3D^\circ$	1	*36954.20*	
				86.50
		2	*37040.70*	
				163.87
		3	*37204.57*	
$3d^3\ (^4F)\ 4p$	$^5F^\circ$	1	—	
		2	—	
		3	—	
		4	*37150.42*	
				201.94
		5	*37352.36*	
$3d^3\ (^4F)\ 4p$	$^5D^\circ$	0	*37201.04*	
				58.00
		1	*37259.04*	
				109.60
		2	*37368.64*	
				151.50
		3	*37520.14*	
				10.50
		4	*37530.64*	

VANADIUM II

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3\,(^4F)\,4p$	$^3G^\circ$	3	*37233.60*	
				169.65
		4	*37403.25*	
				209.12
		5	*37612.37*	
$3d^3\,(^3F)\,4p$	$^5F^\circ$	2	*40001.19*	
				193.80
		3	*40194.99*	
				234.56
		4	*40429.55*	
$3d^3\,(^4P)\,4p$	$^3P^\circ$	0	—	
		1	*45738.5*	
				384.3
		2	*46122.8*	
$3d^3\,(^4P)\,4p$	$^5D^\circ$	0	*46585.7*	
				104.2
		1	*46689.88*	
				49.6
		2	*46739.5*	
				441.3
		3	*47180.82*	
				238.95
		4	*47419.77*	
$3d^3\,(^4P)\,4p$	$^5P^\circ$	1	*46753.98*	
				125.48
		2	*46879.46*	
				171.99
		3	*47051.45*	
—	$^3H^\circ$	4	*47055.83*	
				240.75
		5	*47396.58*	
				310.70
		6	*47607.28*	
$3d^3\,(^4P)\,4p$	$^5S^\circ$	2	*49731.0*	
—	$^3I^\circ$	5	*52082.38*	
				70.59
		6	*52152.97*	
				99.40
		7	*52252.37*	
—	$^3I^\circ$	5	*52877.45*	
				198.81
		6	*53076.26*	
				242.69
		7	*53318.95*	
$3d^3\,(^4P)\,4p$?	$^3S^\circ$	1	*58460.9*	
$3d^3\,(^4F)\,4d$	^5H	3	72446.1	
				103.6
		4	72549.7	
				129.1
		5	72678.8	
				156.8
		6	72835.6	
				182.5
		7	73018.1	

V III $Z = 23$

21 electrons $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ {}^4F_{1\frac{1}{2}}$

First ionization potential = 26.4 volts

Classification is given by White from a study of the isoelectronic sequence. The absolute value of the lowest state is estimated to be 214000 cm.$^{-1}$ with respect to $3d^2\ {}^3F$ of V IV.

Reference

H. E. White, *Phys. Rev.* **33**, 674 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^3$	${}^4F$	$1\frac{1}{2}$	0	
				145
		$2\frac{1}{2}$	145	
				194
		$3\frac{1}{2}$	339	
				244
		$4\frac{1}{2}$	583	
$3d^3$	${}^2P$	$\frac{1}{2}$	11207	
				180
		$1\frac{1}{2}$	11387	
$3d^3$	${}^4P$	$\frac{1}{2}$	11513	
				77
		$1\frac{1}{2}$	11590	
				181
		$2\frac{1}{2}$	11771	
$3d^3$	${}^2G$	$3\frac{1}{2}$	11966	
				221
		$4\frac{1}{2}$	12187	
$3d^3$	${}^2D$	$1\frac{1}{2}$	16229	
				147
		$2\frac{1}{2}$	16376	
$3d^3$	${}^2H$	$4\frac{1}{2}$	16822	
				155
		$5\frac{1}{2}$	16977	
$3d^2\ ({}^3F)\ 4s$	${}^4F$	$1\frac{1}{2}$	43941	
				167
		$2\frac{1}{2}$	44108	
				236
		$3\frac{1}{2}$	44344	
				301
		$4\frac{1}{2}$	44645	
$3d^2\ ({}^3F)\ 4s$	${}^2F$	$2\frac{1}{2}$	49329	
				478
		$3\frac{1}{2}$	49807	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2\,(^3F)\,4p$	$^4G^\circ$	$2\frac{1}{2}$	*85523*	
				351
		$3\frac{1}{2}$	*85874*	
				431
		$4\frac{1}{2}$	*86305*	
				503
		$5\frac{1}{2}$	*86808*	
$3d^2\,(^3F)\,4p$	$^4F^\circ$	$1\frac{1}{2}$	*86716*	
				221
		$2\frac{1}{2}$	*86937*	
				281
		$3\frac{1}{2}$	*87218*	
				326
		$4\frac{1}{2}$	*87544*	
$3d^2\,(^3F)\,4p$	$^2F^\circ$	$2\frac{1}{2}$	*87881*	
				448
		$3\frac{1}{2}$	*88329*	
$3d^2\,(^3F)\,4p$	$^2D^\circ$	$1\frac{1}{2}$	*88560*	
				386
		$2\frac{1}{2}$	*88946*	
$3d^2\,(^3F)\,4p$	$^4D^\circ$	$\frac{1}{2}$	*89004*	
				187
		$1\frac{1}{2}$	*89191*	
				267
		$2\frac{1}{2}$	*89458*	
				−40
		$3\frac{1}{2}$	*89418*	
$3d^2\,(^3F)\,4p$	$^2G^\circ$	$3\frac{1}{2}$	*91712*	
				343
		$4\frac{1}{2}$	*92055*	
$3d^2\,(^3F)\,4d$	^4H	$3\frac{1}{2}$	141269	
				217
		$4\frac{1}{2}$	141486	
				247
		$5\frac{1}{2}$	141733	
				258
		$6\frac{1}{2}$	141991	

V IV $\quad Z = 23$

20 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^2\; {}^3F_2$

Ionization potential = 48 volts

The classification is taken from a paper by White. The estimated absolute value of the lowest state is 391000 cm.$^{-1}$ with respect to $3d\; {}^2D$ of V V.

Reference

H. E. White, *Phys. Rev.* **33**, 542 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^2$	${}^3F$	2	0	
				318
		3	318	
				412
		4	730	
$3d^2$	${}^1D$	2	11658	
$3d^2$	${}^3P$	0	13121	
				117
		1	13238	
				215
		2	13453	
$3d^2$	${}^1G$	4	19087	
$3d^2$	${}^1S$	0	20091	
$3d\,4s$	${}^3D$	1	96195	
				215
		2	96410	
				385
		3	96795	
$3d\,4s$	${}^1D$	2	100902	
$4p$	${}^1D^\circ$	2	*144974*	
$4p$	${}^3D^\circ$	1	*146116*	
				310
		2	*146426*	
				425
		3	*146851*	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d\,4p$	$^3F^\circ$	2	*147133*	
				520
		3	*147653*	
				712
		4	*148365*	
$4p$	$^3P^\circ$	1	*151424*	
				−22
		0	*151446*	
		2	*151564*	
$4p$	$^1F^\circ$	3	*154618*	
$4p$	$^1P^\circ$	1	*156265*	
$4d$	^3G	3	217835	
				262
		4	218097	
				364
		5	218461	
$4d$	^3F	2	223510	
				323
		3	223833	
				430
		4	224263	

V V $Z = 23$

19 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3d\ {}^2D_{1\frac{1}{2}}$

Ionization potential = 64 volts

The classification has been given by Gibbs and White. The lowest state $3d\ {}^2D_{1\frac{1}{2}}$ probably has an absolute value of about 520000 cm.$^{-1}$.

Reference

R. C. Gibbs and H. E. White, *Phys. Rev.* **33**, 157 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	0 620	620
$4s$	^2S	$\frac{1}{2}$	148100	
$4p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*206347* *207617*	1270
$5s$	^2S	$\frac{1}{2}$	328167	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*348584* ?	
$6s$	^2S	$\frac{1}{2}$	403933	

74 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^{14}\ 5s^2\ 5p^6\ 5d^4\ 6s^2\ {}^5D_0$

These terms were kindly given to us by Dr. Laporte.

References

O. LAPORTE, unpublished material.
H. BEINING, *Zeits. f. Physik.* **42**, 146 (1927). Zeeman effects.

Configuration	Symbol	J	Term value
$5d^4\ 6s^2$	^5D	0	0.00
		1	1670.27
		2	3325.50
		3	4829.99
		4	6219.30
$5d^5\ 6s$	^7S	3	2951.27
—	1	4	12161.96
	2	1	13307.09
	3	3	13348.53
	4	2	13777.71
	5	2	14976.21
	6	3	17701.16
	7	2	18116.83
	8°	2	*18532.94*
	9	3	18974.48
	10	2	19253.59

(*Continued*)

Configuration	Symbol	J	Term value
—	11	5	19826.06
	12°	1	*20064.23*
	13°	2	*21126.17*
	14°	1	*21453.79*
	15	4	22476.65
	16°	2	*23047.19*
	17°	2	*23964.58*
	18°	4	*24890.13*
	19°	4	*25287.08*
	20°	1	*25983.57*
	21°	3	*26189.11*
	22°	2	*26229.70*
	23°	2	*26367.22*
	24°	3	*27488.04*
	25°	2	*27662.43*
	26°	1	*27778.45*
	27°	1	*27889.57*
	28°	1	*28198.84*
	29°	5 ?	*28600.79*
	30°	4	*28797.21*
	31°	3	*29139.09*
	32°	2	*29195.84*

(*Continued*)

Configuration	Symbol	*J*	Term value
—	33°	2	*29393.38*
	34°	3	*29912.81*
	35°	3	*30586.61*
	36°	1	*30683.43*
	37°	1 ?	*31170.53*
	38°	1	*31323.45*
	39°	4	*31432.85*
	40°	2	*31817.60*
	41°	3	*32238.00*
	42°	4	*32828.09*
	43°	3	*32957.56*
	44°	2	*33141.38*
	45°	3	*34228.57*
	46°	3	*34353.98*
	47°	2	*34485.88*
	48°	4	*34632.61*
	49°	1	*34719.32*
	50°	4	*35116.71*
	51°	2	*35731.94*
	52°	3	*36082.19*
	53°	1	*36190.42*
	54°	5	*36275.08*

(*Continued*)

Configuration	Symbol	J	Term value
—	55°	2	36672.67
	56°	3	36874.31
	57°	2	36904.13
	58°	4	37146.29
	59°	2	37476.26
	60°	3	37674.04
	61°	1	37773.94
	62°	3	38052.95
	63°	3	38206.41
	64°	4	38259.33
	65°	4	38748.40
	66°	2	39030.29
	67°	2	39245.80
	68°	5	39360.98
	69°	3	39646.35
	70°	2	39707.02
	71°	4	39721.90
	72°	2	40011.38
	73°	3	40233.94
	74°	3	40279.25
	75°	1	40411.05
	76°	3	40665.86

(*Concluded*)

Configuration	Symbol	J	Term value
—	77°	1	*40770.66*
	78°	2	*40868.27*
	79°	4	*40923.77*
	80°	4	*41198.07*
	81°	3	*41499.33*
	82°	2	*41583.10*
	83°	3	*41694.24*
	84°	2	*41734.06*
	85°	3	*42251.41*
	86°	3	*42601.02*
	87°	4	*42910.71*
	88°	4	*43250.93*
	89	1	43451.86
	90°	3 ?	*43850.64*
	91°	2	*43975.05*
	92°	3	*44446.93*
	93	0	45225.23
	94°	4	*45262.48*
	95°	4	*45869.00*
	96°	3	*46067.90*
	97°	4	*46625.03*

54 electrons

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^6\ {}^1S_0$

Ionization potential = 12.078 volts

This classification of the arc spectrum of xenon is taken for the most part from the work of Meggers, De Bruin, and Humphreys.

References

W. F. Meggers, T. L. de Bruin, and C. J. Humphreys, *Bur. Stand. Journ. Res.* **3**, 731 (1929).
W. Gremmer, *Zeits. f. Physik.* **59**, 154 (1930).

Paschen notation	Configuration	Symbol	J	Term value
	$5p^6$	^1S	0	97835.3
$1s_5$	$5p^5\ (^2P_{1\frac{1}{2}})\ 6s$	1°	2	*30766.98*
$1s_4$		2°	1	*29789.34*
$1s_3$	$5p^5\ (^2P_{\frac{1}{2}})\ 6s$	3°	0	*21637.74*
$1s_2$		4°	1	*20649.44*
$2p_{10}$	$5p^5\ (^2P_{1\frac{1}{2}})\ 6p$	1	1	20565.33
$2p_9$		2	2	19714.72
$2p_8$		3	3	19431.51
$2p_7$		4	1	18878.50
$2p_6$		5	2	18622.04
$2p_5$		6	0	17715.59
$3d_6$	$5p^5\ (^2P_{1\frac{1}{2}})\ 5d$	1°	0	*18063.13*
$3d_4'$		2°	4	*17636.85*
$3d_4$		3°	3	*17511.89*
$3d_2$		4°	1	—
$3d_5$		5°	1	*17847.94*
$3d_1''$		6°	2	*16863.49*
$3d_1'$		7°	3	*15907.90*

XENON I

(*Concluded*)

Paschen notation	Configuration	Symbol	J	Term value
$2s_5$	$5p^5\ (^2P_{1\frac{1}{2}})\ 7s$	$1°$	2	—
$2s_4$		$2°$	1	*13944.1*
$3p_{10}$	$5p^5\ (^2P_{1\frac{1}{2}})\ 7p$	1	1	9907.29
$3p_9$		2	2	9482.80
$3p_8$		3	3	9365.27
$3p_7$		4	1	9089.92
$3p_6$		5	2	9147.97
$3p_5$		6	0	8992.20
$2p_4$	$5p^5\ (^2P_{\frac{1}{2}})\ 6p$	7	1	9455.37
$2p_3$		8	2	8672.18
$2p_2$		9	1	8555.78
$2p_1$		10	0	7974.43

SERIES

$5p^6\ ^1S_0$
97835.3

m	$5p^5\ (^2P_{1\frac{1}{2}})\ ms$		$5p^5\ (^2P_{\frac{1}{2}})\ ms$	
	$1_2°$	$2_1°$	$3_0°$	$4_1°$
6	*30766.98*	*29789.34*	*21637.74*	*20649.44*
7	—	*13944.1*	*4835.76*	*4768.8*
8	*7029.96*	*6902.07*		
9	*4436.21*	*4412.35*		
10	*3074.36*	*3047.28*		
11	*2255.67*	*2242.54*		

(*Continued*)

$5p^5\ (^2P_{1\frac{1}{2}})\ mp$

m	p_{10} 1_1	p_9 2_2	p_8 3_3	p_7 4_1	p_6 5_2	p_5 6_0
6	20565.33	19714.72	19431.51	18878.50	18622.04	17715.59
7	9907.29	9482.80	9365.27	9089.92	9147.97	8992.20
8	5681.21	5613.10	5569.61	5501.53	5463.48	5279.09
9	3767.26	3724.37	3700.06	3665.64	3644.40	3549.35
10	2679.00	2652.83	2637.91	2618.04	2604.93	2548.67
11			1976.92	1963.65	1956.43	1918.66
12			1536.42		1522.83	

$5p^5\ (^2P_{\frac{1}{2}})\ mp$

m	p_4 7_1	p_3 8_2	p_2 9_1	p_1 10_0
6	9455.37	8672.18	8555.78	7974.43

$5p^5\ (^2P_{1\frac{1}{2}})\ md$

m	d_6 1_0°	d_4' 2_4°	d_4 3_3°	d_2 4_1°	d_5 5_1°	d_1'' 6_2°	d_1' 7_3°
6	*18063.13*	*17636.85*	*17511.89*	—	*17847.94*	*16863.49*	*15907.90*
7	*9125.98*	*8922.80*	*8809.56*	*9284.67*	*8591.24*	*8289.42*	*8299.90*
8	*5574.55*	*5389.60*	*5188.33*	*5155.94*	*5120.42*	*5112.94*	*5101.14*
9	*3710.08*	*3608.29*	*3544.26*	*3606.38*	*3548.81*	*3494.90*	*3464.47*
10	*2654.60*	*2584.53*	*2551.44*	*2606.01*	*2559.92*	*2521.17*	*2499.72*
11	*2033.69*	*1942.03*	*1922.12*	*1921.19*	*1929.64*	*1902.54*	*1887.64*
12	*1505.57*	*1512.63*	*1499.95*	*1519.37*	*1505.40*	*1485.91*	*1475.54*
13		*1211.83*	*1202.71*		*1205.32*		*1184.64*

$5p^5\ (^2P_{\frac{1}{2}})\ md$

m	s_1'' 9_2°	s_1'''' 10_3°	s_1''' 11_2°	s_1' 12_1°
6	*6387.01*	*6087.89*	*5706.16*	*5574.55*

XENON I

(Concluded)

$5p^5\ (^2P_{1\frac{1}{2}})\ mf$						
m	X 1_1	Y 2_2	Z 3_3	U 4_3	V 5_2	W 6_3
4	6994.68	6985.03	6972.73	6927.30	6924.40	6889.21
5	4471.82	4468.35	4455.97	4433.20	4430.38	4412.59
6	3099.40	3097.50	3089.26	3076.37	3074.46	3063.94
7	2273.04	2272.14	2266.31	2258.67	2257.26	2250.14
8	1737.83	1737.15	1732.92	1728.89	1727.45	1721.99
9	1369.62	1369.62	1367.71	1364.65		
10	1110.11	1110.11	1106.75			

Xe III $Z = 54$

52 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^{10}\,5s^2\,5p^4\;{}^3P_2$

This classification has been given by Deb and Dutt. It is surprising that the $5d\,{}^5D$ is inverted.

Reference

S. C. Deb and A. K. Dutt, *Zeits. f. Physik.* **67**, 138 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5p^3\,6s$	${}^5S°$	2	*0*	
$5p^3\,5d$	${}^5D°$	4	*958*	
				−427
		3	*1385*	
				−214
		2	*1599*	
				−114
		1	*1713*	
				−52
		0	*1764*	
$5p^3\,6p$	${}^5P$	1	25732	
				291
		2	26023	
				415
		3	26438	
$5p^3\,7s$	${}^5S°$	2	*50833*	
$5p^3\,6d$	${}^5D°$	0	*62873*	
				60
		1	*62933*	
				65
		2	*62998*	
				96
		3	*63094*	
				132
		4	*63226*	

Y I $\qquad Z = 39$

39 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d\,5s^2\;{}^2D_{1\frac{1}{2}}$

Ionization potential = 6.5 volts

These terms are taken from a paper by Meggers and Russell. For a few of the multiplets the assignment of electron configurations is not quite certain.

The absolute value of the lowest state is about 53000 cm.$^{-1}$ with respect to $5s^2\,{}^1S$ of Y II.

Reference

W. F. Meggers and H. N. Russell, *Bur. Stand. Journ. Res.* **2,** 733 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\ 5s^2$	^2D	$1\frac{1}{2}$	0.0	
				530.5
		$2\frac{1}{2}$	530.5	
$5s^2\ 5p$	$^2P^\circ$	$\frac{1}{2}$	*10529.2*	
				830.5
		$1\frac{1}{2}$	*11359.7*	
$4d^2\ (^3F)\ 5s$	^4F	$1\frac{1}{2}$	10937.4	
				141.2
		$2\frac{1}{2}$	11078.6	
				199.4
		$3\frac{1}{2}$	11278.0	
				254.1
		$4\frac{1}{2}$	11532.1	
$4d\ 5s\ (^3D)\ 5p$	$^4F^\circ$	$1\frac{1}{2}$	*14949.0*	
				296.8
		$2\frac{1}{2}$	*15245.8*	
				466.6
		$3\frac{1}{2}$	*15712.4*	
				522.1
		$4\frac{1}{2}$	*16234.5*	
$4d^2\ (^3P)\ 5s$	^4P	$\frac{1}{2}$	15221.7	
				107.3
		$1\frac{1}{2}$	15329.0	
				147.7
		$2\frac{1}{2}$	15476.7	
$4d^2\ (^3F)\ 5s$	^2F	$2\frac{1}{2}$	15326.8	
				537.6
		$3\frac{1}{2}$	15864.4	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\ (^1D)\ 5s$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	15994.0 16158.8	164.8
$4d\ 5s\ (^1D)\ 5p$	$^2D°$	$2\frac{1}{2}$ $1\frac{1}{2}$	*16066.0* *16146.1*	−80.1
$4d\ 5s\ (^3D)\ 5p$	$^4D°$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	*16435.8* *16597.3* *16816.6* *17116.3*	161.5 219.3 299.7
$4d^2\ (^1G)\ 5s$	^2G	$4\frac{1}{2}$ $3\frac{1}{2}$	18499.2 18512.4	−13.2
$4d\ 5s\ (^3D)\ 5p$	$^4P°$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*18976.3* *19027.5* *19148.0*	51.2 120.5
$4d^2\ (^3P)\ 5s$	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	19237.7 19406.1	168.4
$4d\ 5s\ (^1D)\ 5p$	$^2F°$	$2\frac{1}{2}$ $3\frac{1}{2}$	*21528.6* *21915.4*	386.8
$4d\ 5s\ (^3D)\ 5p$	$^2D°$	$1\frac{1}{2}$ $2\frac{1}{2}$	*24131.2* *24746.6*	615.4
$4d\ 5s\ (^3D)\ 5p$	$^2F°$	$2\frac{1}{2}$ $3\frac{1}{2}$	*24518.8* *24899.5*	380.7
$4d\ 5s\ (^1D)\ 5p$	$^2P°$	$1\frac{1}{2}$ $\frac{1}{2}$	*24480.6* *24698.8*	−218.2
$4d\ 5s\ (^3D)\ 5p$	$^2P°$	$\frac{1}{2}$ $1\frac{1}{2}$	*27824.5* *28139.6*	315.1
$4d^2\ (^3F)\ 5p$	$^4G°$	$2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$	*28694.0* *28988.9* *29364.2* *29820.4*	294.9 375.3 456.2
$4d^3$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	29272.0 29420.3 29613.6 29842.6	148.3 193.3 229.0

YTTRIUM I

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\ (^3F)\ 5p$	$^4F^\circ$	$1\frac{1}{2}$	*31508.4*	
		$2\frac{1}{2}$	*31680.0*	171.6
		$3\frac{1}{2}$	*31909.2*	229.2
		$4\frac{1}{2}$	*32188.1*	278.9
$5s^2\ 6s$	^2S	$\frac{1}{2}$	31671.6	
$4d^3$	^4P	$\frac{1}{2}$	31977.5	
		$1\frac{1}{2}$	32091.0	113.5
		$2\frac{1}{2}$	32366.3	275.3
$4d\ 5s\ (^3D)\ 6s$	^4D	$\frac{1}{2}$	33148.3	
		$1\frac{1}{2}$	33237.8	89.5
		$2\frac{1}{2}$	33411.5	173.7
		$3\frac{1}{2}$	33752.7	341.2
$4d^2\ (^3F)\ 5p$	$^4D^\circ$	$\frac{1}{2}$	*33215.4*	
		$1\frac{1}{2}$	*33265.3*	49.9
		$2\frac{1}{2}$	*33357.6*	92.3
		$3\frac{1}{2}$	*33614.5*	256.9
$4d^2\ (^3F)\ 5p$	$^2G^\circ$	$3\frac{1}{2}$	*33432.3*	
		$4\frac{1}{2}$	*33788.8*	356.5
$4d^2\ (^3F)\ 5p$	$^2F^\circ$	$2\frac{1}{2}$	*33608.2*	
		$3\frac{1}{2}$	*34029.8*	421.6
$5s\ 5p^2$?	^2P	$\frac{1}{2}$	33613.2	
		$1\frac{1}{2}$	33842.3	229.1
$4d^2\ (^3F)\ 5p$	$^2D^\circ$	$1\frac{1}{2}$	*33906.8*	
		$2\frac{1}{2}$	*34247.7*	340.9
$5s\ 5p^2$	^4P	$\frac{1}{2}$	33911.5	
		$1\frac{1}{2}$	34155.8	244.3
		$2\frac{1}{2}$	34521.2	365.4
$5s\ 5p^2$?	^2D	$1\frac{1}{2}$	34231.2	
		$2\frac{1}{2}$	34257.4	26.2
$4d^2\ (^3P)\ 5p$	$^2S^\circ$	$\frac{1}{2}$	*34438.2*	
$4d^2\ (^3P)\ 5p$	$^4D^\circ$	$\frac{1}{2}$	*35816.7*	
		$2\frac{1}{2}$	*36061.0*	
		$1\frac{1}{2}$	*36135.7*	
		$3\frac{1}{2}$	*36361.3*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\ 5s\ (^3D)\ 6s$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	36420.5 36431.0	10.5
$4d^2\ (^1D)\ 5p$	$^2D°$	$1\frac{1}{2}$ $2\frac{1}{2}$	*36452.3* *36618.5*	166.2
$4d^2\ (^3P)\ 5p$	$^4S°$	$1\frac{1}{2}$	*36750.8*	
—	1	$2\frac{1}{2}$	37074.1	
$4d^2\ (^3P)\ 5p$	$^4P°$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	*37039.5* *37148.5* *37476.0*	109.0 327.5
$4d^2\ (^1D)\ 5p$	$^2P°$	$1\frac{1}{2}$ $\frac{1}{2}$	*37243.7* *37279.3*	−35.6
$4d^2\ (^1D)\ 5p$	$^2F°$	$2\frac{1}{2}$ $3\frac{1}{2}$	*37412.9* *37619.8*	206.9
$4d^2\ (^1G)\ 5p$	$^2H°$	$4\frac{1}{2}$ $3\frac{1}{2}$	*37588.2* *37967.2*	−379.0
$4d\ 5s\ (^3D)\ 5d$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	38469.9 38543.7 38675.4 38865.6	73.8 131.7 190.2
$4d^2\ (^1G)\ 5p$	$^2G°$	$3\frac{1}{2}$ $4\frac{1}{2}$	*38479.0* *38596.7*	117.7
$4d\ 5s\ (^3D)\ 5d$	^4G	$2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$	38635.6 38762.0 38949.3 39223.0	126.4 187.3 273.7
$4d\ 5s\ (^3D)\ 5d$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	39445.3 39565.0 39757.8 39963.8	118.7 192.8 206.0
$4d\ 5s\ (^3D)\ 5d$	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	— 40455.1 40517.1	62.0

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\ (^3P)\ 5p$	$^2D°$	$1\frac{1}{2}$ $2\frac{1}{2}$	*40636.3* *40672.4*	36.1
$5s^2\ 5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	42655.8 43069.8	414.0
$5s\ 5p^2$?	^2S	$\frac{1}{2}$	42685.5	
$4d^2\ (^1G)\ 5p$	$^2F°$	$2\frac{1}{2}$ $3\frac{1}{2}$	*42857.9* *42994.8*	136.9
$4d^2\ (^3F)\ 5d$?	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	43095.7 43337.5 43704.4 44190.5	241.8 366.9 486.1
$5s^2\ 7s$	^2S	$\frac{1}{2}$	43643.9	
$4d^2\ (^3F)\ 6s$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	— 44053.0 ? 44365.7 44759.6	312.7 393.9
$4d\ 5s\ (^3D)\ 7s$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	— — 44655.0 44922.1	267.1
—	2	$1\frac{1}{2}$, $\frac{1}{2}$	44984.5	
$4d\ 5p^2$	^4D	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$	44660.2 44748.3 45008.3 45204.0	88.1 260.0 195.7
$4d\ 5p^2$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	44742.6 ? 45069.3 45388.5 45796.5	326.7 319.2 408.0
—	3	$3\frac{1}{2}$	45663.5	
$4d\ 5p^2$?	^2P	$\frac{1}{2}$ $1\frac{1}{2}$	45947.5 45994.0	46.5
$4d^2\ (^3P)\ 6s$?	^4P	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	— — 50254.0	

Y II $Z = 39$

38 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,5s^2\ {}^1S_0$

First ionization potential = 12.3 volts

This classification is according to the work of Meggers and Russell. The absolute value of the lowest state is 100000 cm.$^{-1}$ with respect to $4d\ {}^2D$ of Y III.

Reference

W. F. MEGGERS and H. N. RUSSELL, *Bur. Stand. Journ. Res.* **2,** 733 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$5s^2$	^1S	0	0.00	
$4d\ 5s$	^3D	1	840.18	
				204.91
		2	1045.09	
				404.79
		3	1449.88	
$4d\ 5s$	^1D	2	3296.27	
$4d^2$	^3F	2	8003.12	
				324.89
		3	8328.01	
				415.38
		4	8743.39	
$4d^2$	^3P	0	13883.47	
				134.86
		1	14018.33	
				79.84
		2	14098.17	
$4d^2$	^1D	2	14832.91	
$4d^2$	^1G	4	15683.0	
$5s\ 5p$	$^3P^\circ$	0	*23445.10*	
				331.16
		1	*23776.26*	
				870.94
		2	*24647.18*	
$4d\ 5p$	$^1D^\circ$	2	*26147.21*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\ 5p$	$^3F^\circ$	2	*27226.97*	
		3	*27532.22*	305.25
		4	*28394.31*	862.09
$4d\ 5p$	$^1P^\circ$	1	*27516.71*	
$4d\ 5p$	$^3D^\circ$	1	*28595.25*	
		2	*28730.05*	134.80
		3	*29214.07*	484.02
$4d\ 5p$	$^3P^\circ$	0	*32048.82*	
		1	*32124.13*	75.31
		2	*32283.58*	159.45
$4d\ 5p$	$^1F^\circ$	3	*33336.74*	
$5s\ 5p$	$^1P^\circ$	1	*44568.2*	
$4d\ 6s$	^3D	1	54955.6	
		2	55032.0	76.4
		3	55645.4	613.4
$4d\ 6s$	^1D	2	55724.9	
$5s\ 6s$	^3S	1	58261.7	
$4d\ 5d$	^1F	3	58533.0	
$4d\ 5d$	^3D	1	58719.7	
		2	58946.6	226.8
		3	59327.1	428.6
$5p^2$	^3P	0	58775.7	
		1	59147.2	371.5
		2	59669.6	522.4
$4d\ 5d$	^3G	3	59178.9	
		4	59471.8	292.9
		5	59900.9	428.6
$4d\ 5d$	^1S	0	59615.8 ?	
$4d\ 5d$	^1P	1	59715.4	

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\ 5d$	^1D	2	60535.1	
$4d\ 5d$	^3S	1	61200.2	
$4d\ 5d$	^3F	2	61336.7	
				313.8
		3	61650.5	
				283.6
		4	61934.1	
$5s\ 6s$	^1S	0	61367.3	
$5s\ 5d$	^1D	2	62495.2	
$4d\ 5d$	^1G	4	63350.0	
$4d\ 5d$	^3P	0	64102.9	
				159.8
		1	64262.7	
				334.4
		2	64597.1	
$5s\ 5d$	^3D	1	65131.5	
				57.2
		2	65188.7	
				86.3
		3	65275.0	
$5p^2$	^1D	2	70223.2	

Y III $Z = 39$

37 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d\ {}^2D_{1\frac{1}{2}}$

Ionization potential = 20.4 volts

These terms are taken from a paper by Meggers and Russell. The absolute value of the lowest state is given as 165000 cm.$^{-1}$.

References

I. S. Bowen and R. A. Millikan, *Phys. Rev.* **28,** 923 (1928).
W. F. Meggers and H. N. Russell, *Bur. Stand. Journ. Res.* **2,** 736 (1929).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d$	^2D	$1\frac{1}{2}$	0.0	724.8
		$2\frac{1}{2}$	724.8	
$5s$	^2S	$\frac{1}{2}$	7466.2	
$5p$	$^2P^\circ$	$\frac{1}{2}$	*41401.2*	1553.5
		$1\frac{1}{2}$	*42954.7*	
$6s$	^2S	$\frac{1}{2}$	86713.9	
$5d$	^2D	$1\frac{1}{2}$	88378.8	198.3
		$2\frac{1}{2}$	88577.1	
$4f$	$^2F^\circ$	$2\frac{1}{2}, 3\frac{1}{2}$	*101090.0*	

Zn I $\qquad Z = 30$

30 electrons $\qquad 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ {}^1S_0$

Ionization potential = 9.36 volts

The classification of this spectrum can be found in Fowler and Paschen-Götze, except for the p^2 configuration which has been discovered by Sawyer.

The first table gives the low terms only; the next one the p^2 configuration; the others, the terms in series arrangement.

Reference

R. A. SAWYER, *Journ. Opt. Soc. Am.* **13**, 431 (1926).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4s^2$	^1S	0	75766.8	
$4s\,4p$	$^3P^\circ$	0	*43455.0*	
				189.8
		1	*43265.2*	
				388.9
		2	*42876.3*	
$4p$	$^1P^\circ$	1	*29021.7*	
$5s$	^3S	1	22094.4	
$5s$	^1S	0	19978.7	
$5p$	$^3P^\circ$	0	*14519.4*	
				26.7
		1	*14492.7*	
				56.2
		2	*14436.5*	
$4d$	^1D	2	13308.6	
$4d$	^3D	1	12997.6	
				3.4
		2	12994.2	
				5.5
		3	12988.7	
$5p$	$^1P^\circ$	1	*12857.9*	
$6s$	^3S	1	10334.4	

ZINC I

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
4s 6s	^1S	0	9729.5	
6p	$^3P^\circ$	0	*7695.8*	
		1	*7686.0*	
		2	*7664.9*	
5d	^1D	2	7428.9	
5d	^3D	1	7187.0	1.1
		2	7185.9	2.0
		3	7183.9	
6p	$^1P^\circ$	1	*7160.0*	
4f	^3F	2, 3, 4	6931.3	
$4p^2$	^3P	0	−4410	219
		1	−4629	
		2	—	
$4p^2$	^1D	2	−5027	

SERIES

4s ms		
m	$^3S_1$	$^1S_0$
4		75766.8
5	22094.4	19978.7
6	10334.4	9729.5
7	6020.5	5763.7
8	3944.1	3812.5
9	2781.2	2709.4
10	2068.0	
11	1597.6	
12	1270.8	

4s mf	
m	$^3F^\circ_{2,3,4}$
4	*6931.3*

(Concluded)

4s mp				
m	$^3P_0^\circ$	$^3P_1^\circ$	$^3P_2^\circ$	$^1P_1^\circ$
4	*43455.0*	*43265.2*	*48276.3*	*29021.7*
5	*14519.4*	*14492.7*	*14436.5*	*12857.9*
6	*7695.8*	*7686.0*	*7664.9*	*7160.6*
7	*4789.2*	*4784.5*	*4774.2*	*4559.1*
8	*3270.2*	*3267.6*	*3262.0*	*3141.7*
9	*2375.9*	*2374.0*	*2370.3*	*2298.2*
10				*1755.5*

4s md				
m	$^3D_1$	$^3D_2$	$^3D_3$	$^1D_2$
4	12997.6	12994.2	12988.7	13308.6
5	7187.0	7185.9	7183.9	7428.9
6	4553.3	(Unresolved)		4719.2
7	3138.7			3276
8	2295.5			
9	1749.9			
10	1378.9			
11	1115.3			
12	911.5			
13	707.6			
14	654.4			

Zn II $Z = 30$

29 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s\ ^2S_{\frac{1}{2}}$

First ionization potential = 17.89 volts

The latest contribution has been made by Takahashi from whose paper this table has been taken. The numbered terms arise very probably from configurations involving the $3d^9$ group. The first table gives the low terms only. The second table contains the remainder of the numbered terms and the other tables contain terms in series arrangement. The doublet separations of the $3d^{10}\,mf\ ^2F$ terms are irregular.

References

Y. Takahashi, *Ann. d. Physik.* **3**, 27 (1929).
G. von Salis, *Ann. d. Physik.* **76**, 145 (1925).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^{10}\,4s$	^2S	$\frac{1}{2}$	144890.23	
$4p$	$^2P^\circ$	$\frac{1}{2}$	*96410.05*	873.53
		$1\frac{1}{2}$	*95536.52*	
$3d^9\ 4s^2$	^2D	$2\frac{1}{2}$	82169.02	−2719.06
		$1\frac{1}{2}$	79449.96	
$3d^{10}\,5s$	^2S	$\frac{1}{2}$	56454.42	
$4d$	^2D	$2\frac{1}{2}$	47982.20	50.78
		$1\frac{1}{2}$	47931.42	
$5p$	$^2P^\circ$	$\frac{1}{2}$	*43525.38*	245.08
		$1\frac{1}{2}$	*43280.30*	
—	1°	$1\frac{1}{2}$ or $2\frac{1}{2}$	*35076.96 ?*	
	2°	$1\frac{1}{2}$ or $2\frac{1}{2}$	*34219.18*	

(*Concluded*)

Configuration	Symbol	J	Term value	
—	3°	$1\frac{1}{2}$?	*33149.41 ?*	
	4°	$1\frac{1}{2}$?	*32899.49*	
	5°	$\frac{1}{2}$	*32368.10*	
	6°	$\frac{1}{2}$	*32311.49*	
	7°	$\frac{1}{2}$	*31393.68*	
	8°	$1\frac{1}{2}$ or $2\frac{1}{2}$	*30847.91*	
	9°	$1\frac{1}{2}$ or $2\frac{1}{2}$	*30059.17*	
$3d^{10}\ 6s$	^2S	$\frac{1}{2}$	30393.87	
$4f$	$^2F^\circ$	$2\frac{1}{2}$, $3\frac{1}{2}$	*27628.04*	
—	10°	$1\frac{1}{2}$ or $2\frac{1}{2}$	*13242.88*	
	11	—	5375.23 ?	
	12	$1\frac{1}{2}$ or $2\frac{1}{2}$?	3707.48 ?	
	13	$\frac{1}{2}$ or $1\frac{1}{2}$?	−4566.26 ?	
	14	$\frac{1}{2}$ or $1\frac{1}{2}$?	−5339.64 ?	
	15	$\frac{1}{2}$ or $1\frac{1}{2}$?	−5390.92 ?	
	16	$\frac{1}{2}$ or $1\frac{1}{2}$?	−8378.93 ?	
	17	$\frac{1}{2}$ or $1\frac{1}{2}$?	−9033.24 ?	
	18	$\frac{1}{2}$ or $1\frac{1}{2}$?	−9574.75 ?	
	19	$\frac{1}{2}$ or $1\frac{1}{2}$?	−10310.67 ?	
	20	$1\frac{1}{2}$ or $2\frac{1}{2}$?	−10980.25 ?	
	21	$1\frac{1}{2}$ or $2\frac{1}{2}$?	−11396.40 ?	

ZINC II

SERIES

$3d^{10}\,mp$		
m	$^2P_{\frac{1}{2}}^{\circ}$	$^2P_{1\frac{1}{2}}^{\circ}$
4	*96410.05*	*95536.52*
5	*43525.38*	*43280.30*
6	*25002.43*	*24931.55*
7	*16256.17*	*16219.03*

$3d^{10}\,ms$	
m	$^2S_{\frac{1}{2}}$
4	144890.23
5	56454.42
6	30393.87
7	19011.64
8	13014.23
9	9468.07

$3d^{10}\,md$		
m	$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
4	47982.20	47931.42
5	26922.39	26898.19
6	17261.33	17248.32
7	12010.17	12003.03
8	8838.99	8834.48
9	6777.03	6773.82

$3d^{10}\,mf$		
m	$^2F_{2\frac{1}{2}}^{\circ}$	$F_{3\frac{1}{2}}^{\circ}$
4	(Unres.)	*27628.04*
5	*17681.10*	*17691.71*
6	*12287.28*	*12252.08*
7	*8999.18*	*9001.96*
8	(Unres.)	*6885.07*

$3d^9\,4s^2$	
$^2D_{1\frac{1}{2}}$	$^2D_{2\frac{1}{2}}$
79449.96	82169.02

$3d^{10}\,mg$	
m	$^2G_{3\frac{1}{2},\,4\frac{1}{2}}$
5	12207.29
6	8968.12

Zn III $Z = 30$

28 electrons $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\ {}^1S_0$

First ionization potential = 40 volts

This classification is given by Laporte and Lang. The absolute value of the lowest state is about 320000 cm.$^{-1}$ with respect to $3d^9\ {}^2D$ of Zn IV.

Reference

O. Laporte and R. J. Lang, *Phys. Rev.* **30**, 378 (1927).

Configuration	Symbol	J	Term value	$\Delta\nu$
$3d^{10}$	^1S	0	0	
$3d^9\,4s$	^3D	3	78105	
				−1178
		2	79283	
				−1576
		1	80859	
$4s$	^1D	2	83509	
$4p$	$^3P^\circ$	2	*137876*	
				−2204
		1	*140080*	
				−1321
		0	*141401*	
$4p$	$^3F^\circ$	3	*140664*	
		4	*141335*	
		2	*142491*	
$4p$	$^3D^\circ$	3	*144511*	
				−741
		2	*145252*	
				−2253
		1	*147505*	
$4p$	$^1P^\circ$	1	*147577*	
$4p$	$^1D^\circ$	2	*147928*	
$4p$	$^1F^\circ$	3	*145974*	

Zr I $Z = 40$

40 electrons $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4d^2\, 5s^2\; {}^3F_2$

Ionization potential = 6.92 volts

With the analysis by Kiess and Kiess, the arc spectrum of zirconium becomes one of the most completely known of the complex spectra. Nearly all the terms of the $4d^3\, 5p$ configuration have been found including all of those based on the two different ${}^2D$ terms of $4d^3$. In these tables of terms the higher of these ${}^2D$ basis terms has been written in square brackets to distinguish it from the lower.

The absolute value of the lowest term $4d^2\, 5s^2\; {}^3F_2$ has been given as 56077 cm.$^{-1}$.

Reference

C. C. Kiess and H. K. Kiess, *Bur. Stand. Journ. Res.* **6**, 621 (1931).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\, 5s^2$	${}^3F$	2	0.00	
				570.41
		3	570.41	
				670.43
		4	1240.84	
$4d^2\, 5s^2$	${}^3P$	0	4196.85	
				179.43
		1	4376.28	
				−190.17
		2	4186.11	
$4d^3\, ({}^4F)\, 5s$	${}^5F$	1	4870.53	
				152.88
		2	5023.41	
				225.66
		3	5249.07	
				291.47
		4	5540.54	
				348.39
		5	5888.93	
$4d^2\, 5s^2$	${}^1D$	2	5101.68	
$4d^2\, 5s^2$	${}^1G$	4	8057.30	
$4d^3\, ({}^4P)\, 5s$	${}^5P$	1	10885.36	
				131.29
		2	11016.65	
				241.73
		3	11258.38	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^3$ (^4F) $5s$	^3F	2	11640.72	315.61
		3	11956.33	386.04
		4	12342.37	
$4d^3$ (^2G) $5s$	^3G	3	12503.44	257.22
		4	12760.66	12.12
		5	12772.78	
$4d^2\ 5s^2$	^1S	0	13141.76	
$4d^3$ (^2D) $5s$	^3D	1	14123.01	225.77
		2	14348.78	348.25
		3	14697.03	
$4d^2\ 5s$ (^4F) $5p$	$^5G^\circ$	2	*14783.54*	417.72
		3	*15201.26*	519.10
		4	*15720.36*	596.60
		5	*16316.96*	661.33
		6	*16978.29*	
$4d^3$ (^2H) $5s$	^3H	4	14791.28	197.23
		5	14988.51	131.15
		6	15119.66	
$4d^3$ (^2F) $5s$	^3F	2	15146.48	310.92
		3	15457.40	242.46
		4	15699.86	
$4d^3$ (^4P) $5s$	^3P	0	—	
		1	—	
		2	15932.10	
$4d^2\ 5s$ (^4F) $5p$	$^3F^\circ$	2	*16296.51*	547.42
		3	*16843.93*	712.33
		4	*17556.26*	
$4d^2\ 5s$ (^4F) $5p$	$^5F^\circ$	1	*16786.93*	272.68
		2	*17059.61*	362.56
		3	*17422.17*	410.56
		4	*17832.73*	444.19
		5	*18276.92*	
$4d^3$ (^2D) $5s$	^1D	2	17228.42	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^3\ (^2P)\ 5s$	^3P	0	17321.52	
		1	17059.82	−261.70
		2	17142.72	82.90
$4d^2\ 5s\ (^4F)\ 5p$	$^3D^\circ$	1	*17429.86*	
		2	*17813.64*	383.78
		3	*18243.56*	429.92
$4d^3\ (^2G)\ 5s$	^1G	4	17752.73	
$4d^2\ 5s\ (^2D)\ 5p$	$^1D^\circ$	2	*17511.78*	
$4d^3\ (^2H)\ 5s$	^1H	5	18738.94	
$4d^2\ 5s\ (^4F)\ 5p$	$^5D^\circ$	0	*18976.36*	
		1	*19096.53*	120.17
		2	*19323.84*	227.31
		3	*19625.58*	301.74
		4	*19833.78*	208.20
$4d^2\ 5s\ (^2P)\ 5p$	$^3P^\circ$	0	*20233.97*	
		1	*20519.20*	285.23
		2	*20466.83*	−52.37
$4d^4$	^5D	0	21726.28	
		1	21801.21	74.93
		2	21943.74	142.53
		3	22145.31	201.57
		4	22398.00	252.69
$4d^2\ 5s\ (^4F)\ 5p$	$^3G^\circ$	3	*21849.33*	
		4	*22144.08*	294.75
		5	*22563.89*	419.81
$4d^2\ 5s\ (^2P)\ 5p$	$^3S^\circ$	1	*21974.18*	
$4d^2\ 5s\ (^2P)\ 5p$	$^1D^\circ$	2	*22750.53*	
$4d^2\ 5s\ (^2D)\ 5p$	$^1F^\circ$	3	*22862.02*	
$4d^2\ 5s\ (^4P)\ 5p$	$^3D^\circ$	1	*23018.92*	
		2	*23319.86*	300.94
		3	*23660.97*	341.11

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\,5s\,(^4P)\,5p$	$^5S^\circ$	2	*23085.06*	
$4d^2\,5s\,(^4P)\,5p$	$^5D^\circ$	0	*23122.29*	
				124.04
		1	*23246.33*	
				243.10
		2	*23489.43*	
				399.60
		3	*23889.03*	
				487.34
		4	*24376.37*	
$4d^3\,(^4F)\,5p$	$^3F^\circ$	2	*23597.47*	
				−30.35
		3	*23567.12*	
				439.18
		4	*24006.30*	
$4d^2\,5s\,(^2F)\,5p$	$^1F^\circ$	3	*24387.52*	
$4d^2\,5s\,(^4P)\,5p$	$^5P^\circ$	1	*25489.87*	
				156.10
		2	*25645.97*	
				252.19
		3	*25898.16*	
$4d^3\,(^4F)\,5p$	$^5G^\circ$	2	*25630.48*	
				341.23
		3	*25971.71*	
				370.82
		4	*26342.53*	
				423.13
		5	*26765.66*	
				449.23
		6	*27214.89*	
$4d^3\,(^4F)\,5p$	$^3G^\circ$	3	*25729.96*	
				281.59
		4	*26011.55*	
				422.17
		5	*26433.72*	
$4d^3\,(^2D)\,5p$	$^1F^\circ$	3	*26226.97*	
$4d^2\,5s\,(^2F)\,5p$	$^1G^\circ$	4	*26931.35*	
$4d^2\,5s\,(^2D)\,5p$	$^3F^\circ$	2	*26061.70*	
				382.18
		3	*26443.88*	
				494.54
		4	*26938.42*	
$4d^2\,5s\,(^2P)\,5p$	$^3D^\circ$	1	*26154.13*	
				403.08
		2	*26557.21*	
				553.95
		3	*27111.16*	
$4d^3\,(^4F)\,5p$	$^3D^\circ$	1	*26902.45*	
				219.51
		2	*27121.96*	
				360.30
		3	*27482.26*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^3\,(^2D)\,5p$	$^1D°$	2	27515.38	
$4d^2\,5s\,(^4P)\,5p$	$^3P°$	0	27600.24	
				−27.72
		1	27572.52	
				100.83
		2	27673.35	
$4d^2\,5s\,(^2F)\,5p$	$^3F°$	2	27876.16	
				281.26
		3	28157.42	
				370.94
		4	28528.36	
$4d^3\,(^2G)\,5p$	$^3H°$	4	27908.28	
				303.54
		5	28211.82	
				396.80
		6	28608.62	
$4d^2\,5s\,(^2F)\,5p$	$^3G°$	3	28404.26	
				345.54
		4	28749.80	
				251.85
		5	29001.65	
$4d^3\,(^4F)\,5p$	$^5F°$	1	28446.92	
				148.11
		2	28595.03	
				222.99
		3	28818.02	
				304.69
		4	29122.71	
				412.77
		5	29535.48	
$4d^2\,5s\,(^2D)\,5p$	$^3P°$	0	28632.75	
				77.13
		1	28709.88	
				199.69
		2	28909.57	
$4d^2\,5s\,(^2D)\,5p$	$^3D°$	1	28800.51	
				257.33
		2	29057.84	
				216.98
		3	29274.82	
$4d^2\,5s\,(^2D)\,5p$	$^1P°$	1	28999.46	
$4d^3\,(^4F)\,5p$	$^5D°$	0	29588.07	
				89.07
		1	29677.14	
				170.35
		2	29847.49	
				239.84
		3	30087.33	
				297.17
		4	30384.50	
$4d^3\,(^2G)\,5p$	$^1G°$	4	31050.48	
$4d^3\,(^2F)\,5p$	$^3G°$	3	31326.81	
				367.71
		4	31694.52	
				457.64
		5	32152.16	

Configuration	Symbol	J	Term value	Δν
$4d^2\,5s\,(^4P)\,5p$	$^3S^\circ$	1	*31850.77*	
$4d^2\,5s\,(^2P)\,5p$	$^1P^\circ$	1	*32722.80*	
$4d^3\,(^2F)\,5p$	$^3F^\circ$	2	*32972.30*	219.56
		3	*33191.86*	496.37
		4	*33688.23*	
$4d^3\,(^4P)\,5p$	$^3S^\circ$	1	*33113.80*	
$4d^3\,(^2D)\,5p$	$^3F^\circ$	2	*33163.98*	256.49
		3	*33420.47*	138.87
		4	*33559.34*	
$4d^3\,(^4P)\,5p$	$^5D^\circ$	0	*33349.56*	95.31
		1	*33444.87*	187.61
		2	*33632.48*	279.61
		3	*33912.09*	375.40
		4	*34287.49*	
$4d^2\,5s\,(^2F)\,5p$	$^3D^\circ$	1	*33486.82*	277.30
		2	*33764.12*	475.70
		3	*34239.82*	
$4d^2\,5s\,(^2G)\,5p$	$^1H^\circ$	5	*33839.20*	
$4d^3\,(^2H)\,5p$	$^3H^\circ$	4	*34450.60*	255.30
		5	*34705.90*	429.17
		6	*35135.07*	
$4d^3\,(^4P)\,5p$	$^5P^\circ$	1	*34617.00*	144.52
		2	*34761.52*	329.38
		3	*35090.90*	
$4d^3\,[^2D]\,5p$	$^1D^\circ$	2	*34850.96*	
$4d^2\,5s\,(^4F)\,6s$	^5F	1	35046.95	163.35
		2	35210.30	265.77
		3	35476.07	384.76
		4	35860.83	499.37
		5	36360.20	
$4d^3\,(^4P)\,5p$	$^3P^\circ$	0	—	
		1	*35205.52*	250.73
		2	*35456.25*	

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\,5s\,(^2G)\,5p$	$^3F^\circ$	2	35514.53	
		3	35805.63	291.10
		4	36001.35	195.72
$4d^3\,(^2H)\,5p$	$^3I^\circ$	5	35781.67	
		6	36173.03	391.36
		7	36152.85	−20.18
$4d^3\,(^4P)\,5p$	$^5S^\circ$	2	35990.21	
$4d^3\,(^2D)\,5p$	$^3P^\circ$	0	36034.54	
		1	36498.10	454.56
		2	37008.40	519.30
$4d^3\,(^4P)\,5p$	$^3D^\circ$	1	36125.16	
		2	36294.87	169.71
		3	36220.45	−74.42
$4d^2\,5s\,(^2G)\,5p$	$^1G^\circ$	4	36336.48	
$4d^3\,[^2D]\,5p$	$^3P^\circ$	0	36538.27	
		1	36970.65	432.38
		2	37450.23	479.58
$4d^2\,5s\,(^2G)\,5p$	$^3H^\circ$	4	36608.41	
		5	36597.48	−10.93
		6	36840.59	243.11
$4d^3\,[^2D]\,5p$	$^1F^\circ$	3	36759.90	
$4d^3\,(^2G)\,5p$	$^3G^\circ$	3	36941.65	
		4	37229.54	287.89
		5	37422.36	192.82
$4d^3\,(^2G)\,5p$	$^3F^\circ$	2	37123.42	
		3	37468.87	345.45
		4	37920.96	452.09
$4d^2\,5s\,(^4F)\,6s$	^3F	2	37459.60	
		3	37701.08	241.48
		4	38101.09	400.01
$4d^3\,(^2F)\,5p$	$^3D^\circ$	1	38270.81	
		2	38326.72	55.91
		3	38435.88	109.16

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^3\ (^2H)\ 5p$	$^1I^\circ$	6	*38475.82*	
$4d^3\ [^2D]\ 5p$	$^3F^\circ$	2	*38566.00*	
		3	*38881.80*	315.80
		4	*39174.44*	292.64
$4d^2\ 5s\ (^2G)\ 5p$	$^3G^\circ$	3	*39389.29*	
		4	*39934.14*	544.85
		5	*40178.44*	244.30
$4d^3\ (^2D)\ 5p$	$^1P^\circ$	1	*39704.10*	
$4d^3\ (^2D)\ 5p$	$^3D^\circ$	1	—	
		2	*39766.47*	
		3	*40346.35*	579.88
$4d^3\ (^2G)\ 5p$	$^1F^\circ$	3	*39803.73*	
$4d^3\ (^2G)\ 5p$	$^1H^\circ$	5	*39855.22*	
$4d^2\ 5s\ (^4F)\ 5d$	^5H	3	—	
		4	39936.70	
		5	40637.05	700.35
		6	41443.53	806.48
		7	42086.82	643.29
$4d\ 5s^2\ (^2D)\ 5p$	$^3P^\circ$	0	*40536.38*	
		1	*40973.94*	437.56
		2	*41787.62*	813.68
$4d^3\ (^2F)\ 5p$	$^1D^\circ$	2	*40557.65*	
—	^5F	1	—	
		2	—	
		3	40653.41	
		4	40849.70	196.29
		5	41068.00	218.30
$4d^2\ 5s\ (^4F)\ 5d$	^5G	2	40660.65	
		3	40887.61	226.96
		4	41179.30	291.69
		5	41538.23	358.93
		6	41940.86	402.63

ZIRCONIUM I

(Concluded)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^3\ [^2D]\ 5p$	$^1P^{\circ}$	1	*40931.60*	
$4d^3\ (^2H)\ 5p$	$^1G^{\circ}$	4	*41319.96*	
$4d^3\ (^2H)\ 5p$	$^3G^{\circ}$	3	*42102.56*	
		4	*42272.41*	169.85
		5	*42834.96*	562.55
$4d^3\ [^2D]\ 5p$	$^3D^{\circ}$	1	*42296.80*	
		2	*42433.65*	136.85
		3	*42799.20*	365.55
$4d^3\ (^2H)\ 5p$	$^1H^{\circ}$	5	*42309.29*	
$4d\ 5s^2\ (^2D)\ 5p$	$^3F^{\circ}$	2	*42706.00*	
		3	*43268.24*	562.24
		4	*43276.00*	7.76
$4d^3\ (^2P)\ 5p$	$^3S^{\circ}$	1	*43182.96*	
$4d^3\ (^2P)\ 5p$	$^3P^{\circ}$	0	—	
		1	*44882.30*	
		2	*45017.13*	134.83
$4d^3\ (^2P)\ 5p$	$^3D^{\circ}$	1	*45405.30*	
		2	*45587.62*	182.32
		3	*45710.29*	122.67
$4d^2\ 5p^2$	^5G	2	45798.48	
		3	46195.15	396.67
		4	46641.42	446.27
		5	47134.50	493.08
		6	47698.29	563.79
$4d^3\ (^2F)\ 5p$	$^1F^{\circ}$	3	*46328.16*	
$4d\ 5s^2\ (^2D)\ 5p$	$^3D^{\circ}$	1	*47765.56*	
		2	*48133.64*	368.08
		3	*48713.44*	579.80
$4d^2\ 5s\ (^2S)\ 5p$	$^1P^{\circ}$	1	*51899.40*	

Zr II $\qquad Z = 40$

39 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^2\,5s\ {}^4F_{1\frac{1}{2}}$

First ionization potential = 13.97 volts

This quite complete classification has been given by Kiess and Kiess. It is interesting to note that *all* terms of the configuration $4d^2\,5p$ have been found. The absolute value of the lowest state is 113200 with respect to $4d^2\ {}^3F_2$ of Zr III.

Reference

C. C. KIESS and H. K. KIESS, *Bur. Stand. Journ. Res.* **5**, 1205 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\,({}^3F)\,5s$	${}^4F$	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	0.00 314.67 763.44 1322.91	314.67 448.77 558.47
$4d^3$	${}^4F$	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	2572.21 2895.05 3299.64 3757.66	322.84 404.59 458.02
$4d^2\,({}^1D)\,5s$	${}^2D$	$1\frac{1}{2}$ $2\frac{1}{2}$	4248.30 4505.50	257.20
$4d^2\,({}^3P)\,5s$	${}^2P$	$\frac{1}{2}$ $2\frac{1}{2}$	5724.38 6111.70	387.32
$4d^2\,({}^3F)\,5s$	${}^2F$	$2\frac{1}{2}$ $3\frac{1}{2}$	5752.92 6467.61	714.69
$4d^2\,({}^3P)\,5s$	${}^4P$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	7512.67 7736.02 8058.16	223.35 322.14
$4d^3$	${}^2G$	$3\frac{1}{2}$ $4\frac{1}{2}$	7837.74 8152.80	315.06
$4d^3$	${}^4P$	$\frac{1}{2}$ $1\frac{1}{2}$ $2\frac{1}{2}$	9553.10 9742.80 9968.65	189.70 225.85

ZIRCONIUM II

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^3$	^2H	$4\frac{1}{2}$	11984.46	
				375.20
		$5\frac{1}{2}$	12359.66	
$4d^3$	^2D	$1\frac{1}{2}$	13428.50	
				734.40
		$2\frac{1}{2}$	14162.90	
$4d^2\ (^1G)\ 5s$	^2G	$3\frac{1}{2}$	14059.76	
				130.69
		$4\frac{1}{2}$	14190.45	
$4d^3$	^2D	$1\frac{1}{2}$	14298.64	
				434.73
		$2\frac{1}{2}$	14733.37	
$4d\ 5s^2$	^2D	$1\frac{1}{2}$	17614.00	
				782.54
		$2\frac{1}{2}$	18396.54	
$4d^3$	^2F	$3\frac{1}{2}$	19433.24	
				−81.60
		$2\frac{1}{2}$	19514.84	
$4d^3$	^2P	$\frac{1}{2}$	19613.54	
				466.76
		$1\frac{1}{2}$	20080.30	
$4d^2\ (^1S)\ 5s$	^2S	$\frac{1}{2}$	25201.57	
$4d^2\ (^3F)\ 5p$	$^4G^\circ$	$2\frac{1}{2}$	*27983.83*	
				925.21
		$3\frac{1}{2}$	*28909.04*	
				930.83
		$4\frac{1}{2}$	*29839.87*	
				955.87
		$5\frac{1}{2}$	*30795.74*	
$4d^2\ (^3F)\ 5p$	$^2F^\circ$	$2\frac{1}{2}$	*29504.97*	
				1056.78
		$3\frac{1}{2}$	*30561.75*	
$4d^2\ (^3F)\ 5p$	$^4F^\circ$	$1\frac{1}{2}$	*29777.60*	
				773.88
		$2\frac{1}{2}$	*30551.48*	
				697.80
		$3\frac{1}{2}$	*31249.28*	
				617.21
		$4\frac{1}{2}$	*31866.49*	
$4d^2\ (^3F)\ 5p$	$^2D^\circ$	$1\frac{1}{2}$	*30435.38*	
				724.66
		$2\frac{1}{2}$	*31160.04*	
$4d^2\ (^3F)\ 5p$	$^4D^\circ$	$\frac{1}{2}$	*31981.25*	
				275.46
		$1\frac{1}{2}$	*32256.71*	
				358.00
		$2\frac{1}{2}$	*32614.71*	
				284.75
		$3\frac{1}{2}$	*32899.46*	

(*Continued*)

Configuration	Symbol	J	Term value	Δν
$4d^2\ (^3P)\ 5p$	$^2D^\circ$	1½ 2½	*32983.73* *33419.45*	435.72
$4d^2\ (^3F)\ 5p$	$^2G^\circ$	3½ 4½	*34485.42* *35185.64*	700.22
$4d^2\ (^3P)\ 5p$	$^2S^\circ$	½	*34810.03*	
$4d^2\ (^1D)\ 5p$	$^2P^\circ$	1½ ½	*35914.81* *36196.57*	−281.76
$4d^2\ (^3P)\ 5p$	$^4D^\circ$	½ 1½ 2½ 3½	*36237.04* *36638.50* *37171.22* *38041.49*	401.46 532.72 870.27
$4d\ 5s\ (^3D)\ 5p$	$^4F^\circ$	1½ 2½ 3½ 4½	*36451.79* *36869.00* *37429.76* *38644.12*	417.21 560.76 1214.36
$4d^2\ (^1G)\ 5p$	$^2F^\circ$	2½ 3½	*37346.31* *37787.59*	441.28
$4d^2\ (^3P)\ 5p$	$^4S^\circ$	1½	*37681.75*	
$4d\ 5s\ (^3D)\ 5p$	$^4P^\circ$	½ 1½ 2½	*38063.40* *38133.50* *38482.64*	70.10 349.14
$4d\ 5s\ (^3D)\ 5p$	$^4D^\circ$	½ 1½ 2½ 3½	*38934.37* *39192.35* *39640.08* *40238.55*	257.98 447.73 598.47
$4d^2\ (^3P)\ 5p$	$^2P^\circ$	½ 1½	*40727.26* *41337.36*	610.10
$4d^2\ (^1G)\ 5p$	$^2G^\circ$	3½ 4½	*40852.74* *40878.25*	25.51
$4d^2\ (^1D)\ 5p$	$^2D^\circ$	1½ 2½	*41467.72* *41676.82*	209.10

ZIRCONIUM II

(*Continued*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\ (^1G)\ 5p$	$^2H^\circ$	$4\frac{1}{2}$	*41738.21*	
		$5\frac{1}{2}$	*42409.93*	671.72
$4d^2\ (^1D)\ 5p$	$^2F^\circ$	$3\frac{1}{2}$	*42504.11*	
		$2\frac{1}{2}$	*42860.72*	−356.61
$4d^2\ (^3P)\ 5p$	$^4P^\circ$	$\frac{1}{2}$	*42789.24*	
		$1\frac{1}{2}$	*42893.54*	104.30
		$2\frac{1}{2}$	*43202.45*	308.91
$4d\ 5s\ (^1D)\ 5p$	$^2D^\circ$	$1\frac{1}{2}$	*45054.87*	
		$2\frac{1}{2}$	*45186.05*	131.18
$4d^2\ (^1S)\ 5p$	$^2P^\circ$	$1\frac{1}{2}$	*45568.21*	
		$\frac{1}{2}$	*45944.00*	−375.79
$4d\ 5s\ (^1D)\ 5p$	$^2F^\circ$	$2\frac{1}{2}$	*47881.88*	
		$3\frac{1}{2}$	*48344.91*	463.03
$4d\ 5s\ (^1D)\ 5p$	$^2P^\circ$	$\frac{1}{2}$	*52585.80*	
		$1\frac{1}{2}$	*52876.80*	291.00
$4d\ 5s\ (^3D)\ 5p$	$^2D^\circ$	$1\frac{1}{2}$	*55835.53*	
		$2\frac{1}{2}$	*56569.44*	733.91
$4d\ 5s\ (^3D)\ 5p$	$^2F^\circ$	$2\frac{1}{2}$	*57062.00*	
		$3\frac{1}{2}$	*57741.16*	679.16
$4d\ 5s\ (^3D)\ 5p$	$^2P^\circ$	$\frac{1}{2}$	*60814.50*	
		$1\frac{1}{2}$	*61861.90*	1047.40
$4d^2\ (^3F)\ 6s$	^4F	$1\frac{1}{2}$	63602.64	
		$2\frac{1}{2}$	63868.45	265.81
		$3\frac{1}{2}$	64368.28	499.83
		$4\frac{1}{2}$	64901.71	533.43
$4d^2\ (^3F)\ 6s$	^2F	$2\frac{1}{2}$	65872.41	
		$3\frac{1}{2}$	66192.68	320.27
$4d^2\ (^1D)\ 6s$	^2D	$1\frac{1}{2}$	66686.25	
		$2\frac{1}{2}$	66868.35	182.10
$4d^2\ (^1G)\ 6s$	^2G	$3\frac{1}{2}$	69116.70	
		$4\frac{1}{2}$	69283.38	166.68

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2\ (^3F)\ 5d$	^2F	$2\frac{1}{2}$ $3\frac{1}{2}$	73852.95 74496.80	643.85
$4d^2\ (^3F)\ 5d$	^4F	$1\frac{1}{2}$ $2\frac{1}{2}$ $3\frac{1}{2}$ $4\frac{1}{2}$	74611.28 75343.57 76009.05 76593.58	732.29 665.48 584.53
$4d^2\ (^1G)\ 5d$	^2I	$5\frac{1}{2}$ $6\frac{1}{2}$	76395.50 76838.70	443.20
$4d^2\ (^1G)\ 5d$	^2H	$4\frac{1}{2}$ $5\frac{1}{2}$	77743.00 78280.90	537.90
$4d^2\ (^3F)\ 5d$	^4H	$3\frac{1}{2}$ $4\frac{1}{2}$ $5\frac{1}{2}$ $6\frac{1}{2}$	78577.85 78847.67 78198.35 79280.30	269.82 350.68 81.95
$4d^2\ (^1G)\ 5d$	^2G	$3\frac{1}{2}$ $4\frac{1}{2}$	79624.60 80311.54	686.94
$4d^2\ (^3F)\ 5d$	^2G	$3\frac{1}{2}$ $4\frac{1}{2}$	83221.45 83547.45	326.00
$4d^2\ (^3F)\ 5d$	^2H	$4\frac{1}{2}$ $5\frac{1}{2}$	90986.50 91737.40	750.90

Zr III $\qquad Z = 40$

38 electrons $\qquad 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^2\,4p^6\,4d^2\ {}^3F_2$

First ionization potential = 24.00 volts

This classification has been taken from a paper by Kiess and Lang. The absolute value of the lowest state is 194400 cm.$^{-1}$ with respect to $4d\ {}^2D_{1\frac{1}{2}}$ of Zr IV.

Reference

C. C. Kiess and R. J. Lang, *Bur. Stand. Journ. Res.* **5**, 305 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d^2$	^3F	2	0.0	
				682.5
		3	682.5	
				804.3
		4	1486.8	
	^1G	4	2534	
	^1D	2	3392	
	^1S	0	3835	
	^3P	0	8061.4	
				265.4
		1	8326.8	
				513.2
		2	8840.0	
$4d\,5s$	^1D	2	16122.5	
	^3D	1	18398.6	
				403.9
		2	18802.5	
				730.7
		3	19533.2	
$4d\,5p$	$^1D^\circ$	2	*53170.0*	
	$^1P^\circ$	1	*53646.7*	
	$^1F^\circ$	3	*54071.5*	
	$^3F^\circ$	2	*55554.9*	
				519.8
		3	*56074.7*	
				1606.7
		4	*57681.4*	

(*Continued*)

Configuration	Symbol	J	Term value	Δν
4d 5p	$^3D^\circ$	1	*55613.3*	
				822.2
		2	*56435.5*	
				910.9
		3	*57346.4*	
	$^3P^\circ$	0	*59945.6*	
				−284.1
		1	*59697.5*	
				658.9
		2	*60356.4*	
4d 5d	^1S	0	88999	
	^3S	1	94767.3	
	^3D	1	—	
		2	97462.0	
				−31.3
		3	97430.7	
	^1P	1	97879	
	^3P	0	97918.2	
				−5.7
		1	97912.5	
				784.5
		2	98697.0	
	^1D	2	98058	
	^1F	3	101443	
	^3F	2	103839.6	
				632.1
		3	104471.7	
				1116.6
		4	105588.3	
	^3G	3	104635.8	
				556.2
		4	105192.0	
				1112.4
		5	106304.4	
4d 6s	^3D	1	107309.3	
				507.7
		2	107817.0	
				496.0
		3	108313.0	
	^1D	2	107631.5	
4d 4f	$^3F^\circ$	4	*117814*	
				−1712
		3	*119526*	
				−1940
		2	*121466*	

ZIRCONIUM III

(*Concluded*)

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d\ 4f$	$^3G^\circ$	3	*122015*	
				588
		4	*122603*	
				400
		5	*123003*	
	$^3P^\circ$	0	*123392*	
				202
		1	*123594*	
				362
		2	*123956*	
	$^1D^\circ$	2	*126531*	
	$^1P^\circ$	1	*127320*	
	$^1H^\circ$	5	*130002*	
	$^3D^\circ$	1	*131008*	
				510
		2	*131518*	
				680
		3	*132198*	
	$^1G^\circ$	4	*131406*	
	$^1F^\circ$	3	*131736*	

Zr IV $\quad Z = 40$

37 electrons $\quad 1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^{10}\, 4s^2\, 4p^6\, 4d\ ^2D_{1\frac{1}{2}}$

Ionization potential = 33.8 volts

This classification has been taken from a paper by Kiess and Lang. The absolute value of the lowest state is 274067 cm.$^{-1}$.

Reference

C. C. Kiess and R. J. Lang, *Bur. Stand. Journ. Res.* **5**, 305 (1930).

Configuration	Symbol	J	Term value	$\Delta\nu$
$4d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	0 1250	1250
$5s$	^2S	$\frac{1}{2}$	38258	
$5p$	$^2P^\circ$	$\frac{1}{2}$ $1\frac{1}{2}$	*81976* *84462*	2486
$5d$	^2D	$1\frac{1}{2}$ $2\frac{1}{2}$	146650 147001	351
$6s$	^2S	$\frac{1}{2}$	152509	
$4f$	$^2F^\circ$	$2\frac{1}{2}$ $3\frac{1}{2}$	*159068* *159088*	20
$7s$	^2S	$\frac{1}{2}$	198840	

RYDBERG TERM TABLES

Reprinted from the article by F. Paschen, *Journ. Opt. Soc. Am.* **16**, 231 (1928)

TABLE I

Values of $109737.1/(m+a)^2$ and the differences between m and $m+1$

m	1	2	3	4	5	6	7	8	9	10	11	12	13
a +0.00	109737.1	27434.28	12193.01	6858.57	4389.48	3048.25	2239.53	1714.64	1354.78	1097.37	906.92	762.06	649.33
Δ	82302.82	15241.27	5334.44	2469.09	1341.23	808.72	524.89	359.86	257.41	190.45	144.86	112.73	
+0.05	99534.78	26112.34	11796.52	6690.27	4302.99	2998.08	2207.88	1693.41	1339.85	1086.48	898.73	755.75	644.37
Δ	73422.44	14315.82	5106.25	2387.28	1304.91	790.20	514.47	353.56	253.37	187.75	142.98	111.38	
+0.10	90691.82	24883.70	11419.05	6528.08	4219.04	2949.13	2176.89	1672.57	1325.17	1075.75	890.65	749.52	639.46
Δ	65808.12	13464.65	4890.97	2309.04	1269.91	772.24	504.32	347.40	249.42	185.10	141.13	110.06	
+0.15	82977.04	23739.77	11059.42	6371.73	4137.51	2901.37	2146.55	1652.11	1310.72	1065.18	882.68	743.36	634.60
Δ	59237.27	12680.35	4687.69	2234.22	1236.14	754.82	494.44	341.39	245.54	182.50	139.32	108.76	
+0.20	76206.33	22672.95	10716.51	6220.92	4058.33	2854.76	2116.84	1632.02	1296.52	1054.76	874.82	737.28	629.80
Δ	53533.38	11956.44	4495.59	2162.59	1203.57	737.92	484.82	335.50	241.76	179.94	137.54	107.48	
+0.25	70231.75	21676.47	10389.31	6075.41	3981.39	2809.27	2087.75	1612.30	1282.54	1044.49	867.06	731.28	625.06
Δ	48555.28	11287.16	4313.90	2094.02	1172.12	721.52	475.45	329.76	238.05	177.43	135.78	106.22	
+0.30	64933.18	20744.26	10076.87	5934.94	3906.63	2764.86	2059.24	1592.93	1268.78	1034.38	859.40	725.34	620.37
Δ	44188.92	10667.39	4141.93	2028.31	1141.77	705.62	466.31	324.15	234.40	174.98	134.06	104.97	
+0.35	60212.39	19870.91	9778.31	5799.29	3833.95	2721.48	2031.32	1573.91	1255.25	1024.41	851.85	719.48	615.73
Δ	40341.48	10092.60	3979.02	1965.34	1112.47	690.16	457.41	318.66	230.84	172.56	132.37	103.75	
+0.40	55988.32	19051.58	9492.83	5668.24	3763.28	2679.13	2003.96	1555.23	1241.93	1014.58	844.39	713.69	611.14
Δ	36936.74	9558.75	3824.59	1904.96	1084.15	675.17	448.73	313.30	227.35	170.19	130.70	102.55	
+0.45	52193.63	18281.90	9219.67	5541.58	3694.54	2637.75	1977.16	1536.88	1228.82	1004.90	837.03	707.97	606.61
Δ	33911.73	9062.23	3678.09	1847.04	1056.79	660.59	440.28	308.06	223.92	167.87	129.06	101.36	
+0.50	48772.04	17557.94	8958.13	5419.12	3627.67	2597.33	1950.88	1518.85	1215.92	995.35	829.77	702.32	602.12
Δ	31214.10	8599.81	3539.01	1791.45	1030.34	646.45	432.03	302.93	220.57	165.58	127.45	100.20	

(Concluded)

m	1	2	3	4	5	6	7	8	9	10	11	12	13
a +0.55	45676.21	16876.14	8707.56	5300.67	3562.60	2557.83	1925.13	1501.14	1203.22	985.94	822.60	696.73	597.69
Δ		28800.07	8168.58	3406.89	1738.07	1004.77	632.70	423.99	297.92	217.28	163.34	125.87	99.04
+0.60	42866.05	16233.30	8467.37	5186.06	3499.27	2519.22	1899.88	1483.74	1190.72	976.66	815.53	691.21	593.30
Δ		26632.75	7765.93	3281.31	1686.79	980.05	619.34	416.14	293.02	214.06	161.13	124.32	97.91
+0.65	40307.47	15626.50	8236.97	5075.13	3437.61	2481.48	1875.13	1466.63	1178.42	967.51	808.54	685.76	588.96
Δ		24680.97	7389.53	3161.84	1637.52	956.13	606.35	408.50	288.21	210.91	158.97	122.78	96.80
+0.70	37971.32	15053.10	8015.86	4967.73	3377.57	2444.58	1850.85	1449.82	1166.30	958.49	801.64	680.37	584.67
Δ		22918.22	7037.24	3048.13	1590.16	932.99	593.73	401.03	283.52	207.81	156.85	121.27	95.70
+0.75	35832.53	14510.69	7803.53	4863.69	3319.08	2408.50	1827.05	1433.30	1154.37	949.59	794.84	675.05	580.43
Δ		21321.84	6707.16	2939.84	1544.61	910.58	581.45	393.75	278.93	204.78	154.75	119.79	94.62
+0.80	33869.48	13997.08	7599.52	4762.89	3262.10	2373.21	1803.70	1417.06	1142.62	940.82	788.12	669.78	576.23
Δ		19872.40	6397.56	2836.63	1500.79	888.89	569.51	386.64	274.44	201.80	152.70	118.34	93.55
+0.85	32063.44	13510.26	7403.42	4665.20	3206.58	2338.69	1780.80	1401.09	1131.05	932.17	781.48	664.58	572.08
Δ		18553.18	6106.84	2738.22	1458.62	867.89	557.89	379.71	270.04	198.88	150.69	116.90	92.50
+0.90	30398.09	13048.41	7214.80	4570.47	3152.46	2304.92	1758.33	1385.39	1119.65	923.63	774.93	659.44	567.97
Δ		17349.68	5833.61	2644.33	1418.01	847.54	546.59	372.94	265.74	196.02	148.70	115.49	91.47
+0.95	28859.20	12609.84	7033.30	4478.61	3099.70	2271.87	1736.28	1369.96	1108.43	915.22	768.45	654.36	563.90
Δ		16249.36	5576.54	2554.69	1378.91	827.83	535.59	366.32	261.53	193.21	146.77	114.09	90.46
+1.00	27434.28	12193.01	6858.57	4389.48	3048.25	2239.53	1714.65	1354.78	1097.37	906.92	762.06	649.33	559.88
Δ		15241.27	5334.44	2469.09	1341.23	808.72	524.88	359.87	257.41	190.45	144.86	112.73	89.45

$m + a =$	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.50
	121592.4	135477.9	151885.3	171464.2	195088.2	223953.4	259732.8	304825.9	438948.4

TABLE II

Values of $4 \cdot 109737.1/(m + a)^2$ and the differences between m and $m + 1$

a/m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0.00	438948.40	109737.12	48772.04	27434.28	17557.92	12193.00	8958.12	6858.56	5419.12	4389.48	3627.68	3048.24	2597.32	2239.52	0.00
	329211.28	60965.08	21337.76	9876.36	5364.92	3234.88	2099.56	1439.44	1029.64	761.80	579.44	450.92	357.80		
0.05	398139.12	104449.36	47186.08	26761.08	17211.96	11992.32	8831.52	6773.64	5359.40	4345.92	3594.92	3023.00	2577.48	2223.70	0.05
	293689.76	57263.28	20425.00	9549.12	5219.64	3160.80	2057.88	1414.24	1013.48	751.00	571.92	445.52	353.78		
0.10	362767.28	99534.80	45676.20	26112.32	16876.16	11796.52	8707.56	6690.28	5300.68	4303.00	3562.60	2998.08	2557.84	2207.88	0.10
	263232.48	53858.60	19563.88	9236.16	5079.64	3088.96	2017.28	1389.60	997.68	740.40	564.52	440.24	349.96		
0.15	331908.16	94959.08	44237.68	25486.92	16550.04	11605.48	8586.20	6608.44	5242.88	4260.72	3530.72	2973.44	2538.40	2192.39	0.15
	236949.08	50721.40	18750.76	8936.88	4944.56	3019.28	1977.76	1365.56	982.16	730.00	557.28	435.04	346.01		
0.20	304825.32	90691.80	42866.04	24883.68	16233.32	11419.04	8467.36	6528.08	5186.08	4219.04	3499.28	2949.12	2519.20	2176.89	0.20
	214133.52	47825.76	17982.36	8650.36	4814.28	2951.68	1939.28	1342.00	967.04	719.76	550.16	429.92	342.31		
0.25	280927.00	86705.88	41557.24	24301.64	15925.56	11237.08	8351.00	6449.20	5130.16	4177.96	3468.24	2925.12	2500.24	2161.72	0.25
	194221.12	45148.64	17255.60	8376.08	4688.48	2886.08	1901.80	1319.04	952.20	709.72	543.12	424.88	338.52		
0.30	259732.72	82977.04	40307.48	23739.76	15626.52	11059.44	8236.96	6371.72	5075.12	4137.52	3437.60	2901.36	2481.48	2146.55	0.30
	176755.68	42669.56	16567.72	8113.24	4567.08	2822.48	1865.24	1296.60	937.60	699.92	536.24	419.88	334.93		
0.35	240849.56	79483.64	39113.24	23197.16	15335.80	10885.92	8125.28	6295.64	5021.00	4097.64	3407.40	2877.92	2462.92	2131.70	0.35
	161365.92	40370.40	15916.08	7861.36	4449.88	2760.64	1829.64	1274.64	923.36	690.24	529.48	415.00	331.22		
0.40	223953.28	76206.32	37971.32	22672.96	15053.12	10716.52	8015.84	6220.92	4967.72	4058.32	3377.56	2854.76	2444.56	2116.84	0.40
	147746.96	38235.00	15298.36	7619.84	4336.60	2700.68	1794.92	1253.20	909.40	680.76	522.80	410.20	327.72		
0.45	208774.52	73127.60	36878.68	22166.32	14778.16	10551.00	7908.64	6147.52	4915.28	4019.60	3348.12	2831.88	2426.44	2102.30	0.45
	135646.92	36248.92	14712.36	7388.16	4227.16	2642.36	1761.12	1232.24	895.68	671.48	516.24	405.44	324.14		

(*Concluded*)

a/m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
0.50	195088.16	70231.76	35832.52	21676.48	14510.68	10389.32	7803.52	6075.40	4863.68	3981.40	3319.08	2809.28	2408.48	2087.75	0.50
	124856.40	34399.24	14156.04	7165.80	4121.36	2585.80	1728.12	1211.72	882.28	662.32	509.80	400.80	320.73		
0.55	182704.84	67504.56	34830.24	21202.68	14250.40	10231.32	7700.52	6004.56	4812.88	3943.76	3290.40	2786.92	2390.76	2073.50	0.55
	115200.28	32674.32	13627.56	6952.28	4019.08	2530.80	1695.96	1191.68	869.12	653.36	503.48	396.16	317.26		
0.60	171464.20	64933.20	33869.48	20744.24	13997.08	10076.88	7599.52	5934.96	4762.88	3906.64	3262.12	2764.84	2373.20	2059.24	0.60
	106531.00	31063.72	13125.24	6747.16	3920.36	2477.36	1664.56	1172.08	856.24	644.52	497.28	391.64	313.96		
0.65	161229.88	62506.00	32947.88	20300.52	13750.44	9925.92	7500.52	5866.52	4713.68	3870.04	3234.16	2743.04	2355.84	2045.28	0.65
	98723.88	29558.12	12647.36	6550.08	3824.52	2425.40	1634.00	1152.84	843.64	635.88	491.12	387.20	310.56		
0.70	151885.28	60212.40	32063.44	19870.92	13510.28	9778.32	7403.40	5799.28	4665.20	3833.96	3206.56	2721.48	2338.68	2031.32	0.70
	91672.88	28148.96	12192.52	6360.64	3731.96	2374.92	1604.12	1134.08	831.24	627.40	485.08	382.80	307.36		
0.75	143330.12	58042.76	31214.12	19454.76	13276.32	9634.00	7308.20	5733.20	4617.48	3798.36	3179.36	2700.20	2321.72	2017.64	0.75
	85287.36	26828.64	11759.36	6178.44	3642.32	2325.80	1575.00	1115.72	819.12	619.00	479.16	378.48	304.08		
0.80	135477.92	55988.32	30398.08	19051.56	13048.40	9492.84	7214.80	5668.24	4570.48	3763.28	3152.48	2679.12	2304.92	2003.96	0.80
	79489.60	25590.24	11346.52	6003.16	3555.56	2278.04	1546.56	1097.76	807.20	610.80	473.36	374.20	300.96		
0.85	128253.76	54041.04	29613.68	18660.80	12826.32	9354.76	7123.20	5604.36	4524.20	3728.68	3125.92	2658.32	2288.32	1990.51	0.85
	74212.72	24427.36	10952.88	5834.48	3471.56	2231.56	1518.84	1080.16	795.52	602.76	467.60	370.00	297.81		
0.90	121592.36	52193.64	28859.20	18281.88	12609.84	9219.68	7033.32	5541.56	4478.60	3694.52	3099.72	2637.76	2271.88	1977.16	0.90
	69398.72	23334.44	10577.32	5672.04	3390.16	2186.36	1491.76	1062.96	784.08	594.80	461.96	365.88	294.70		
0.95	115436.80	50439.36	28133.20	17914.44	12398.80	9087.48	6945.12	5479.84	4433.72	3660.88	3073.80	2617.44	2255.60	1964.02	0.95
	64997.44	22306.16	10218.76	5515.64	3311.32	2142.36	1465.28	1046.12	772.84	587.08	456.36	361.84	291.58		
1.00	109737.12	48772.04	27434.28	17557.92	12193.00	8958.12	6858.56	5419.12	4389.48	3627.68	3048.24	2597.32	2239.52	1950.88	1.00
	60965.08	21337.76	9876.36	5364.92	3234.88	2099.56	1439.48	1029.64	761.80	579.44	450.92	357.80	288.64		

TABLE III

Values of $9 \cdot 109737.1/(m+a)^2$ and the differences between m and $m+1$

a/m	1	2	3	4	5	6	7	8	9	10	11	12	13	
0.00	987633.90	246908.52	109737.09	61727.13	39505.32	27434.25	20155.77	15431.76	12193.02	9876.33	8162.28	6858.54	5843.97	0.00
	740725.38	137171.43	48009.96	22221.81	12071.07	7278.48	4724.01	3238.74	2316.69	1714.05	1303.74	1014.57		
0.05	895813.20	235011.06	106168.68	60212.43	38726.91	26982.72	19870.92	15240.69	12058.65	9778.32	8088.57	6801.75	5799.33	0.05
	660801.96	128842.38	45956.25	21485.52	11744.19	7111.80	4630.23	3182.04	2280.33	1689.75	1286.82	1002.42		
0.10	816226.38	223953.30	102771.45	58752.72	37971.36	26542.17	19592.01	15053.13	11926.53	9681.75	8015.85	6745.68	5755.14	0.10
	592273.08	121181.85	44018.73	20781.36	11429.19	6950.16	4538.88	3126.60	2244.78	1665.90	1270.17	990.54		
0.15	746793.36	213657.93	99534.78	57345.57	37237.59	26112.33	19318.95	14868.99	11796.48	9586.62	7944.12	6690.24	5711.40	0.15
	533135.43	114123.15	42189.21	20107.98	11125.26	6793.38	4449.96	3072.51	2209.86	1642.50	1253.88	978.84		
0.20	685856.97	204056.55	96448.59	55988.28	36524.97	25692.84	19051.56	14688.18	11668.68	9492.84	7873.38	6635.52	5668.20	0.20
	481800.46	107607.96	40460.31	19463.31	10832.13	6641.28	4363.38	3019.50	2175.84	1619.46	1237.86	967.32		
0.25	632085.76	195088.23	93503.79	54678.69	35832.51	25283.43	18789.75	14510.70	11542.86	9400.41	7803.54	6581.52	5625.54	0.25
	436997.52	101584.44	38825.10	18846.18	10549.08	6493.68	4279.05	2967.84	2142.45	1596.87	1222.02	955.98		
0.30	584398.62	186698.34	90691.83	53414.46	35159.67	24883.74	18533.16	14336.37	11419.02	9309.42	7734.60	6528.06	5583.33	0.30
	397700.28	96006.51	37277.37	18254.79	10275.93	6350.58	4196.79	2917.35	2109.60	1574.82	1206.54	944.73		
0.35	541911.51	178838.19	88004.79	52193.61	34505.55	24493.32	18281.88	14165.19	11297.25	9219.69	7666.65	6475.32	5541.57	0.35
	363073.32	90833.40	35811.18	17688.06	10012.23	6211.44	4116.69	2867.94	2077.56	1553.04	1191.33	933.75		
0.40	503894.88	171464.22	85435.47	51014.16	33869.43	24112.17	18035.64	13997.07	11177.37	9131.22	7599.51	6423.21	5500.26	0.40
	332430.66	86028.75	34421.31	17144.73	9757.26	6076.53	4038.57	2819.70	2046.15	1531.71	1176.30	922.95		
0.45	469742.67	164537.10	82977.03	49874.22	33250.86	23739.75	17794.44	13831.92	11059.38	9044.10	7533.27	6371.73	5459.49	0.45
	305205.57	81560.07	33102.81	16623.36	9511.11	5945.31	3962.52	2772.54	2015.28	1510.83	1161.54	912.24		

(*Concluded*)

a/m	1	2	3	4	5	6	7	8	9	10	11	12	13	
0.50	438948.36	158021.46	80623.17	48772.08	32649.03	23375.97	17557.92	13669.65	10943.28	8958.15	7467.93	6320.88	5419.08	0.50
	280926.90	77398.29	31851.09	16123.05	9273.06	5818.05	3888.27	2726.37	1985.13	1490.22	1147.05	901.80		
0.55	411085.89	151885.26	78368.04	47706.03	32063.40	23020.47	17326.17	13510.26	10828.98	8873.46	7403.40	6270.57	5379.21	0.55
	259200.63	73517.22	30662.01	15642.63	9042.93	5694.30	3815.91	2681.28	1955.52	1470.06	1132.83	891.36		
0.60	385794.45	146099.70	76206.33	46674.54	31493.43	22672.98	17098.92	13353.66	10716.48	8789.94	7339.77	6220.89	5339.70	0.60
	239694.75	69893.37	29531.79	15181.11	8820.45	5574.06	3745.26	2637.18	1926.54	1450.17	1118.88	881.19		
0.65	362767.23	140638.50	74132.73	45676.17	30938.49	22333.32	16876.17	13199.67	10605.78	8707.59	7276.86	6171.84	5300.64	0.65
	222128.73	66505.77	28456.56	14737.68	8605.17	5457.15	3676.50	2593.89	1898.19	1430.73	1105.02	871.20		
0.70	341741.88	135477.90	72142.74	44709.57	30398.13	22001.22	16657.65	13048.38	10496.70	8626.41	7214.76	6123.33	5262.03	0.70
	206263.98	63335.16	27433.17	14311.44	8396.91	5343.57	3609.27	2551.68	1870.29	1411.65	1091.43	861.30		
0.75	322492.77	130596.21	70231.77	43773.21	29871.72	21676.50	16443.45	12899.70	10389.33	8546.31	7153.56	6075.45	5223.87	0.75
	191896.56	60364.44	26458.56	13901.49	8195.22	5233.05	3543.75	2510.37	1843.02	1392.75	1078.11	851.58		
0.80	304825.32	125973.72	68395.68	42866.01	29358.90	21358.89	16233.30	12753.54	10283.58	8467.38	7093.08	6028.02	5186.07	0.80
	178851.60	57578.04	25529.67	13507.11	8000.01	5125.59	3479.76	2469.96	1816.20	1374.30	1065.06	841.95		
0.85	288570.96	121592.34	66630.78	41986.80	28859.22	21048.21	16027.20	12609.81	10179.45	8389.53	7033.32	5981.22	5148.72	0.85
	166978.62	54961.56	24643.98	13127.58	7811.01	5021.01	3417.39	2430.36	1789.92	1356.21	1052.10	832.50		
0.90	273582.81	117435.69	64933.20	41134.23	28372.14	20744.28	15824.97	12468.51	10076.85	8312.67	6974.37	5934.96	5111.73	0.90
	156147.12	52502.49	23798.97	12762.09	7627.86	4919.31	3356.46	2391.66	1764.18	1338.30	1039.41	823.23		
0.95	259732.80	113488.56	63299.70	40307.49	27897.30	20446.83	15626.52	12329.64	9975.87	8236.98	6916.05	5889.24	5075.10	0.95
	146244.24	50188.86	22992.21	12410.19	7450.47	4820.31	3296.88	2353.77	1738.89	1320.93	1026.81	814.14		
1.00	246908.52	109737.09	61727.13	39505.32	27434.25	20155.77	15431.76	12193.02	9876.33	8162.28	6858.54	5843.97	5038.92	1.00
	137171.43	48009.96	22221.81	12071.07	7278.48	4724.01	3238.74	2316.69	1714.05	1303.74	1014.57	805.05		

Table IV

Values of $16 \cdot 109737.1/(m + a)^2$ and the differences between m and $m + 1$

a/m	1	2	3	4	5	6	7	8	9	10	11	12	13	
0.00	1755793.6	438948.5	195088.2	109737.1	70231.7	48772.0	35832.5	27434.2	21676.5	17557.9	14510.7	12193.0	10389.3	0.00
	1316845.1	243860.3	85351.1	39505.4	21459.7	12939.5	8398.3	5757.7	4118.6	3047.2	2317.7	1803.7		
0.05	1592556.5	417797.4	188744.3	107044.3	68847.8	47969.3	35326.1	27094.6	21437.6	17383.7	14379.7	12092.0	10309.9	0.05
	1174759.1	229053.1	81700.0	38196.5	20878.5	12643.2	8231.5	5657.0	4053.9	3004.0	2287.7	1782.1		
0.10	1451069.1	398139.2	182704.8	104449.3	67504.6	47186.1	34830.2	26761.1	21202.7	17212.0	14250.4	11992.3	10231.4	0.10
	1052929.9	215434.4	78255.5	36944.7	20318.5	12355.9	8069.1	5558.4	3990.7	2961.6	2258.1	1760.9		
0.15	1327632.6	379836.3	176950.7	101947.7	66200.2	46421.9	34344.8	26433.8	20971.5	17042.9	14122.9	11893.8	10153.6	0.15
	947796.3	202885.6	75003.0	35747.5	19778.3	12077.1	7911.0	5462.3	3928.6	2920.0	2229.1	1740.2		
0.20	1219301.3	362767.2	171464.2	99534.7	64933.3	45676.2	33869.4	26112.3	20744.3	16876.2	13997.1	11796.5	10076.8	0.20
	856534.1	191303.0	71929.5	34601.4	19257.1	11806.8	7757.1	5368.0	3868.1	2879.1	2200.6	1719.7		
0.25	1123708.0	346823.5	166229.0	97206.6	63702.2	44948.3	33404.0	25796.8	20520.6	16711.8	13873.0	11700.5	10001.0	0.25
	776884.5	180594.5	69022.4	33504.4	18753.9	11544.3	7607.2	5276.2	3808.8	2838.8	2172.5	1699.5		
0.30	1038930.9	331908.2	161229.9	94959.0	62506.1	44237.8	32947.8	25486.9	20300.5	16550.1	13750.4	11605.4	9925.9	0.30
	707022.7	170678.3	66270.9	32452.9	18268.3	11290.0	7460.9	5186.4	3750.4	2799.7	2145.0	1679.5		
0.35	963398.2	317934.6	156453.0	92788.6	61343.2	43543.7	32501.1	25182.6	20084.0	16390.6	13629.6	11511.7	9851.7	0.35
	645463.6	161481.6	63664.4	31445.4	17799.5	11042.6	7318.5	5098.6	3693.4	2761.0	2117.9	1660.0		
0.40	895813.1	304825.3	151885.3	90691.8	60212.5	42866.1	32063.4	24883.7	19870.9	16233.3	13510.2	11419.0	9778.2	0.40
	590987.8	152940.0	61193.5	30479.3	17346.4	10802.7	7179.7	5012.8	3637.6	2723.1	2091.2	1640.8		
0.45	835098.1	292510.4	147514.7	88665.3	59112.6	42204.0	31634.6	24590.1	19661.1	16078.4	13392.5	11327.5	9705.8	0.45
	542587.7	144995.7	58849.4	29552.7	16908.6	10569.4	7044.5	4929.0	3582.7	2685.9	2065.0	1621.7		

(*Concluded*)

a/m	1	2	3	4	5	6	7	8	9	10	11	12	13	
0.50	780352.6	280927.0	143330.1	86705.9	58042.7	41557.3	31214.1	24301.6	19454.7	15925.6	13276.3	11237.1	9633.9	0.50
	499425.6	137596.9	56624.2	28663.2	16485.4	10343.2	6912.5	4846.9	3529.1	2649.3	2039.2	1603.2		
0.55	730819.4	270018.2	139321.0	84810.7	57001.6	40925.3	30802.1	24018.2	19251.5	15775.0	13161.6	11147.7	9563.0	0.55
	460801.2	130697.2	54510.3	27809.1	16076.3	10123.2	6783.9	4766.7	3476.5	2613.4	2013.9	1584.7		
0.60	685856.8	259732.8	135477.9	82977.0	55988.3	40307.5	30398.1	23739.8	19051.5	15626.6	13048.5	11059.4	9492.8	0.60
	426124.0	124254.9	52500.9	26988.7	15680.8	9909.4	6658.3	4688.3	3424.9	2578.1	1989.1	1566.6		
0.65	644919.5	250024.0	131791.5	81202.1	55001.8	39703.7	30002.1	23466.1	18854.7	15480.2	12936.6	10972.2	9423.4	0.65
	394895.5	118232.5	50589.4	26200.3	15298.1	9701.6	6536.0	4611.4	3374.5	2543.6	1964.4	1548.8		
0.70	607541.1	240849.6	128253.8	79483.7	54041.1	39113.3	29613.6	23197.1	18660.8	15335.8	12826.2	10885.9	9354.7	0.70
	366691.5	112595.8	48770.1	25442.6	14927.8	9499.7	6416.5	4536.3	3325.0	2509.6	1940.3	1531.2		
0.75	573320.5	232171.0	124856.5	77819.0	53105.3	38536.0	29232.8	22932.8	18469.9	15193.4	12717.4	10800.8	9286.9	0.75
	341149.5	107314.5	47037.5	24713.7	14569.3	9303.2	6300.0	4462.9	3276.5	2476.0	1916.6	1513.9		
0.80	541911.7	223953.3	121592.3	76206.2	52193.6	37971.4	28859.2	22673.0	18281.9	15053.1	12609.9	10716.5	9219.7	0.80
	317958.4	102361.0	45386.1	24012.6	14222.2	9112.2	6186.2	4391.1	3228.8	2443.2	1893.4	1496.8		
0.85	513015.0	216164.2	118454.7	74643.2	51305.3	37419.0	28492.8	22417.4	18096.8	14914.7	12503.7	10633.3	9153.3	0.85
	296850.8	97709.5	43811.5	23337.9	13886.3	8926.2	6075.4	4320.6	3182.1	2411.0	1870.4	1480.0		
0.90	483369.4	208774.6	115436.8	73127.5	50439.4	36878.7	28133.3	22166.2	17914.4	14778.1	12398.9	10551.0	9087.5	0.90
	277594.8	93337.8	42309.3	22688.1	13560.7	8745.4	5967.1	4251.7	3136.3	2379.2	1847.9	1463.5		
0.95	461747.2	201757.4	112532.8	71657.8	49595.2	36349.9	27780.5	21919.4	17734.9	14643.5	12295.2	10469.8	9022.4	0.95
	259989.8	89224.6	40875.0	22062.6	13245.3	8569.4	5861.1	4184.5	3091.4	2348.3	1825.4	1447.4		
1.00	438948.5	195088.2	109737.1	70231.7	48772.0	35832.5	27434.2	21676.5	17557.9	14510.7	12193.0	10389.3	8958.1	1.00
	243860.3	85351.1	39505.4	21459.7	12939.5	8398.3	5757.7	4118.6	3047.2	2317.7	1803.7	1431.2		

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PHYSICAL CONSTANTS*

Velocity of light	$c = (2.99796 \pm 0.00004) \cdot 10^{10}$ cm./sec.
Electronic charge	$e = (4.770 \pm 0.005) \cdot 10^{-10}$ abs. e.s.u.
Mass of electron	$m_0 = (9.035 \pm 0.010) \cdot 10^{-28}$ g.
Mass of proton	$M = (1.6609 \pm 0.0017) \cdot 10^{-24}$ g.
Planck's constant	$h = (6.547 \pm 0.008) \cdot 10^{-27}$ erg · sec.
Boltzmann constant	$k = (1.3709 \pm 0.0014) \cdot 10^{-16}$ erg/deg.
Unit of angular momentum	$\dfrac{h}{2\pi} = (1.0420 \pm 0.0013) \cdot 10^{-27}$ erg · sec.
Bohr magneton	$\mu_0 = \dfrac{eh}{4\pi m_0 c} = (0.9175 \pm 0.0013) \cdot 10^{-20}$ erg/gauss
Specific electron charge	$\dfrac{e}{m_0 c} = (1.761 \pm 0.001) \cdot 10^{7}$ abs. e.m.u./g.
Hydrogen radius	$a_0 = \dfrac{h^2}{4\pi^2 e^2 m_0} = (0.5285 \pm 0.0004) \cdot 10^{-8}$ cm.
Compton wave length	$\dfrac{h}{m_0 c} = (2.417 \pm 0.005) \cdot 10^{-10}$ cm.
Fine structure constant	$\alpha = \dfrac{2\pi e^2}{hc} = (7.284 \pm 0.006) \cdot 10^{-3}$
	$\dfrac{1}{\alpha} = 137.29 \pm 0.11$
Rydberg constant	$R_\infty = \dfrac{2\pi^2 m_0 e^4}{h^3 c} = 109737.42 \pm 0.06$ cm.$^{-1}$
	$R_\infty \alpha^2 = 5.822 \pm 0.009$ cm.$^{-1}$
Ratio of masses	$\dfrac{M}{m_0} = 1838 \pm 1$

ENERGY CONVERSION FACTORS

$$h c \nu = eV \cdot 10^8/c = kT = \text{ergs}$$

	ν	V	T	Ergs
Wave numbers ν	....	$1.2336 \cdot 10^{-4}$	1.4318	$1.963 \cdot 10^{-16}$
Electron volts V	8106	....	$1.161 \cdot 10^{4}$	$1.591 \cdot 10^{-12}$
Absolute temperature T	0.6984	$8.616 \cdot 10^{-5}$	....	$1.371 \cdot 10^{-16}$
Ergs	$5.094 \cdot 10^{15}$	$6.294 \cdot 10^{11}$	$7.294 \cdot 10^{15}$	....

Use of Table.—If the energy is given in electron volts multiply by 8106 to obtain it in wave numbers.

$R \cdot hc = 109737.42$ cm.$^{-1} \cdot hc = 13.54$ electron volts $\cdot\, e \cdot 10^8/c = 15700$ deg. abs. $\cdot\, k$.

kT at $T = 293$ deg., equals 204.6 cm.$^{-1} \cdot hc$ and 0.02524 electron volts $\cdot\, e \cdot 10^8/c$.

$m_0c^2 = 511{,}120$ electron volts $\cdot\, e \cdot 10^8/c = 4.137 \cdot 10^9$ cm.$^{-1} \cdot hc$.

$Mc^2 = 9.3957 \cdot 10^8$ electron volts.

* From the compilation of R. T. Birge, Phys. Rev. Suppl. 1, 1 (1929).

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(For Introduction)

ALPHABETICAL INDEX OF TABLES